Fig. 1

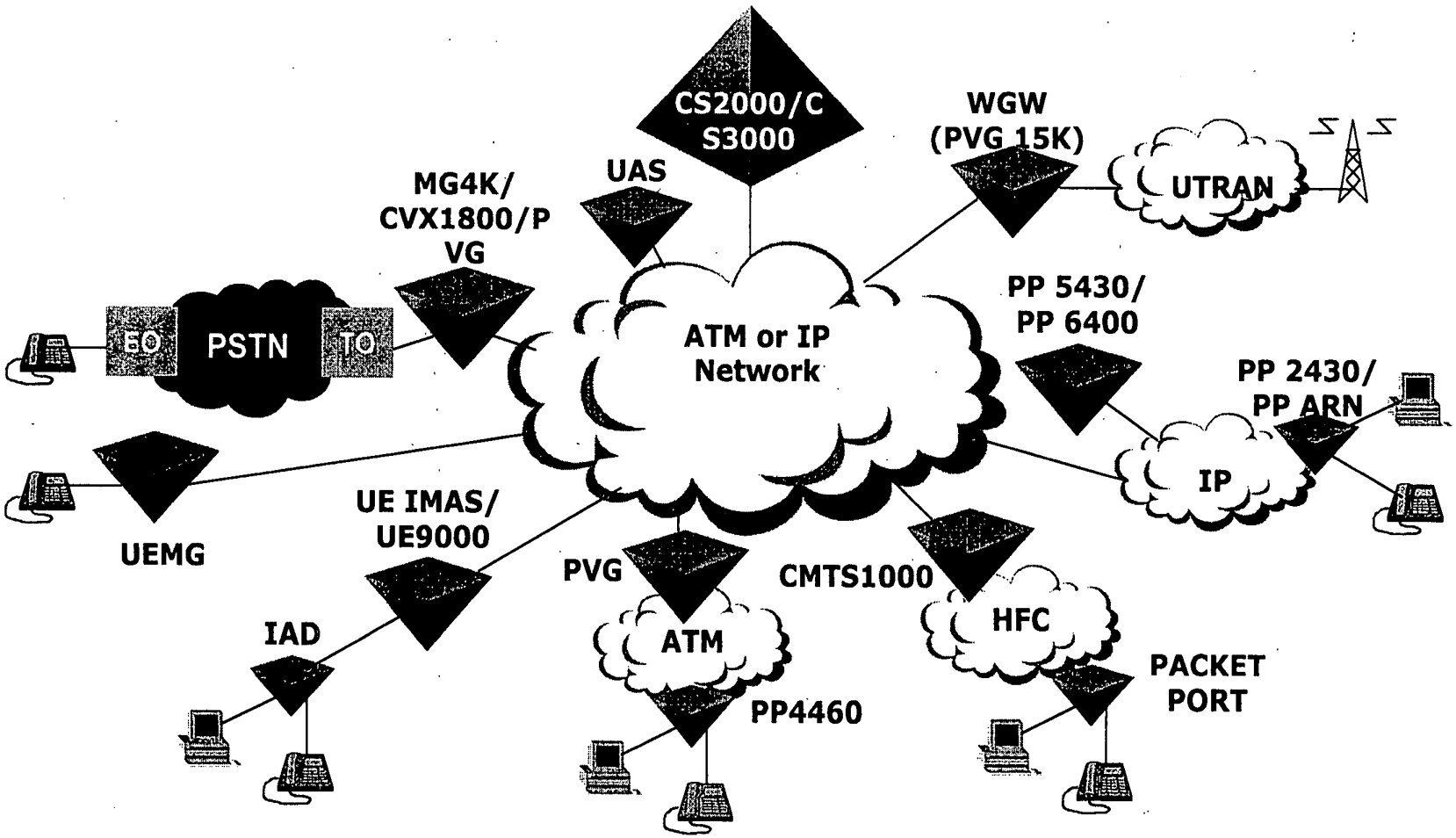
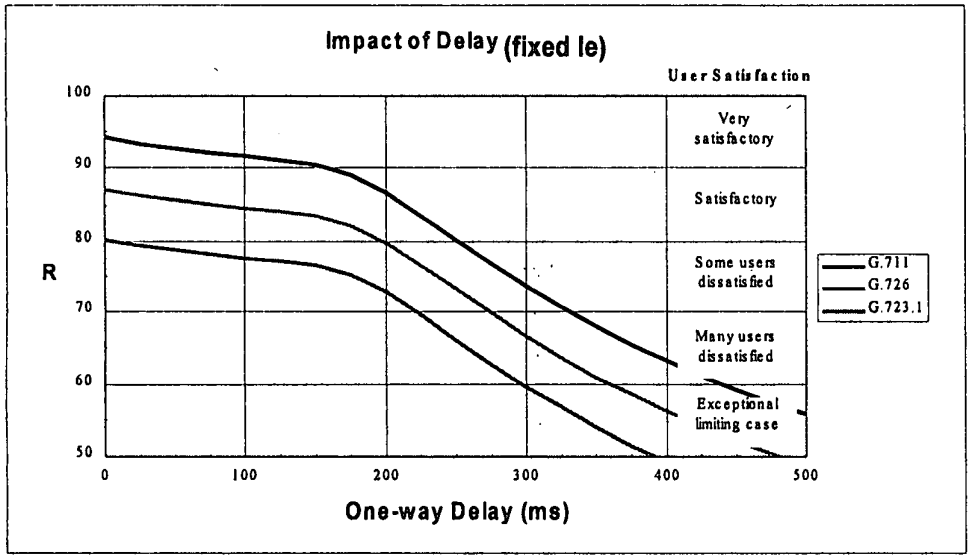


Fig. 2


Impact of Delay (fixed Ie)
User Satisfaction
Very satisfactory
Satisfactory
Some users dissatisfied
Many users dissatisfied
Exceptional limiting case
R
100
90
80
70
60
50
0
100
200
300
400
500
One-way Delay (ms)
G.711
G.726
G.723.1

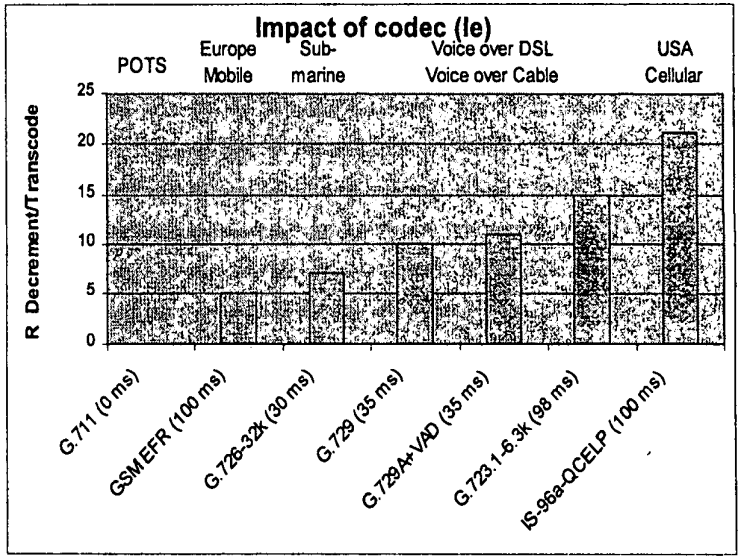

Impact of codec (Ie)
POTS
Europe Mobile
Sub-marine
Voice over DSL
Voice over Cable
USA Cellular
R Decrement/Transcode
25
20
15
10
5
0
G.711 (0 ms)
GSMEFR (100 ms)
G.726-32k (30 ms)
G.729 (35 ms)
G.729A+VAD (35 ms)
G.723.1-6.3k (98 ms)
IS-96a-QCELP (100 ms)

Fig. 3

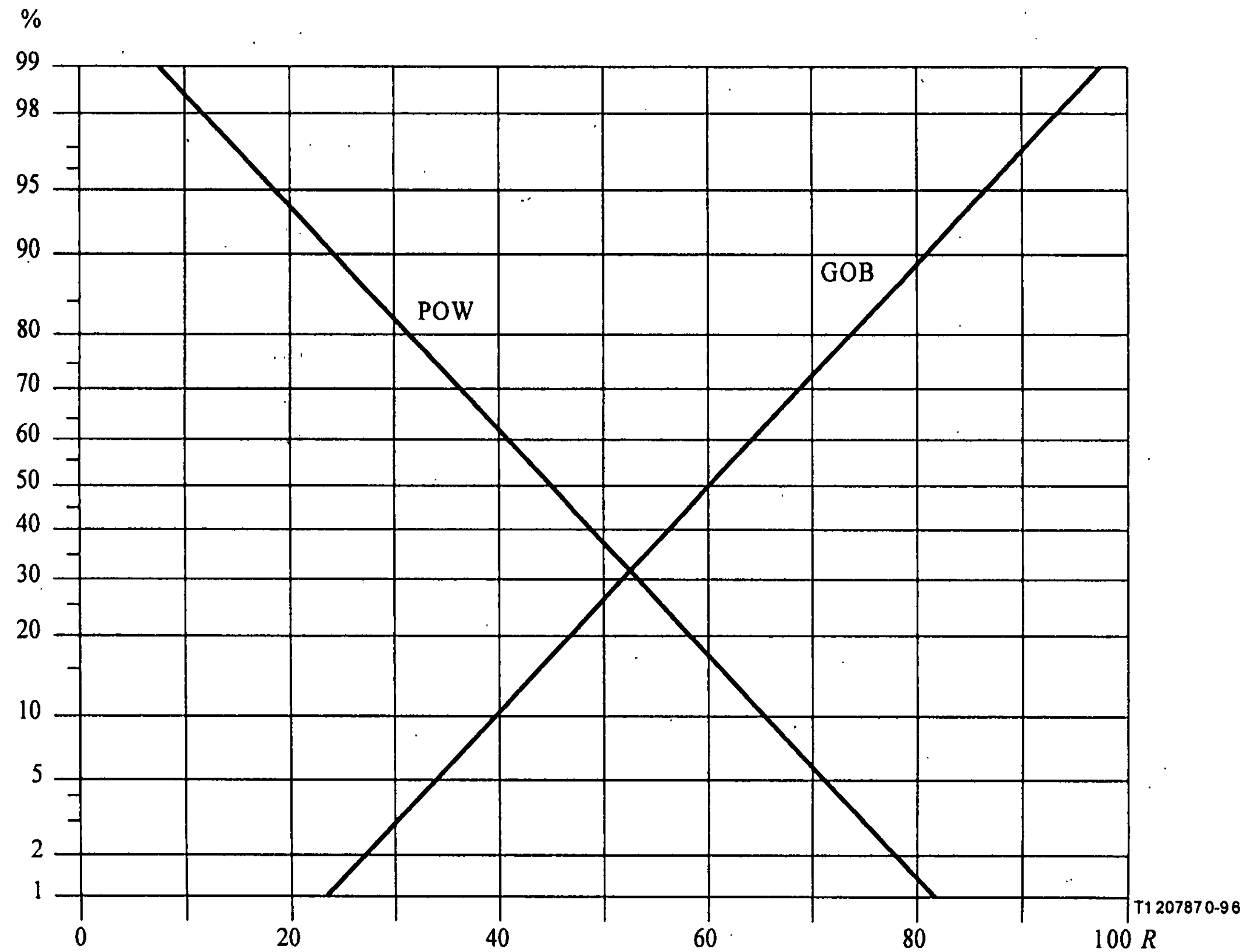


Figure B.1/G.107 - GOB (Good or Better) and POW (Poor or Worse) as functions of rating factor R

Fig. 4

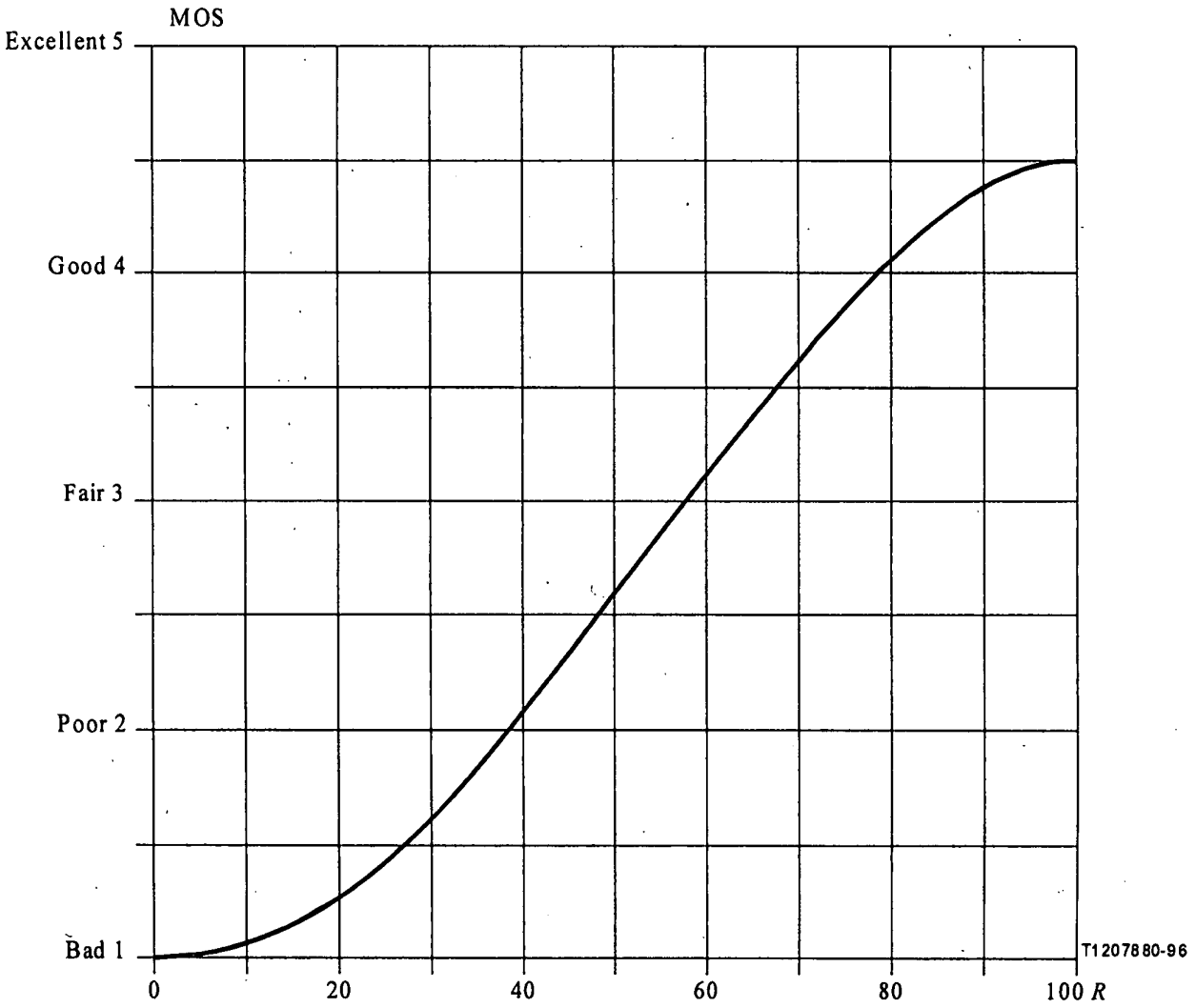


Figure B.2/G.107 – MOS as function of rating factor *R*

Fig. 5

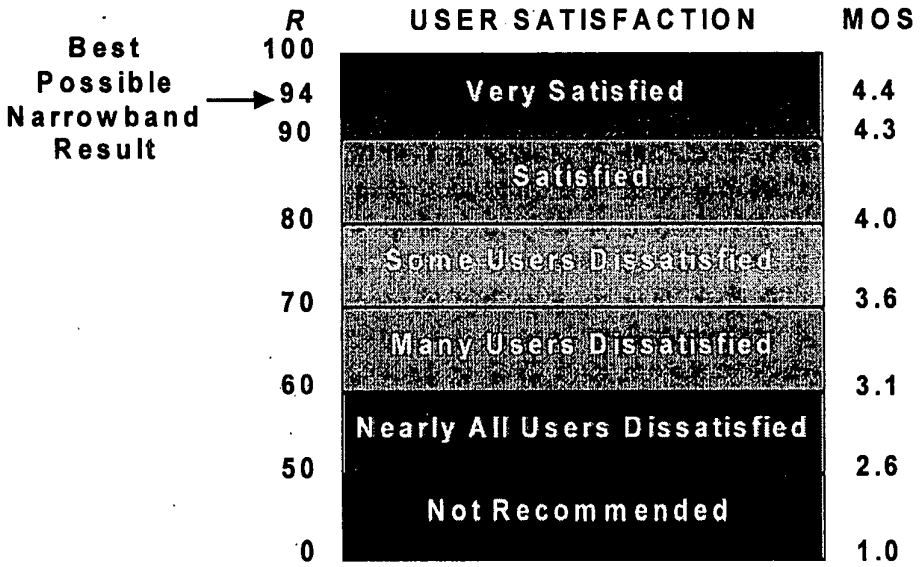


Fig. 6

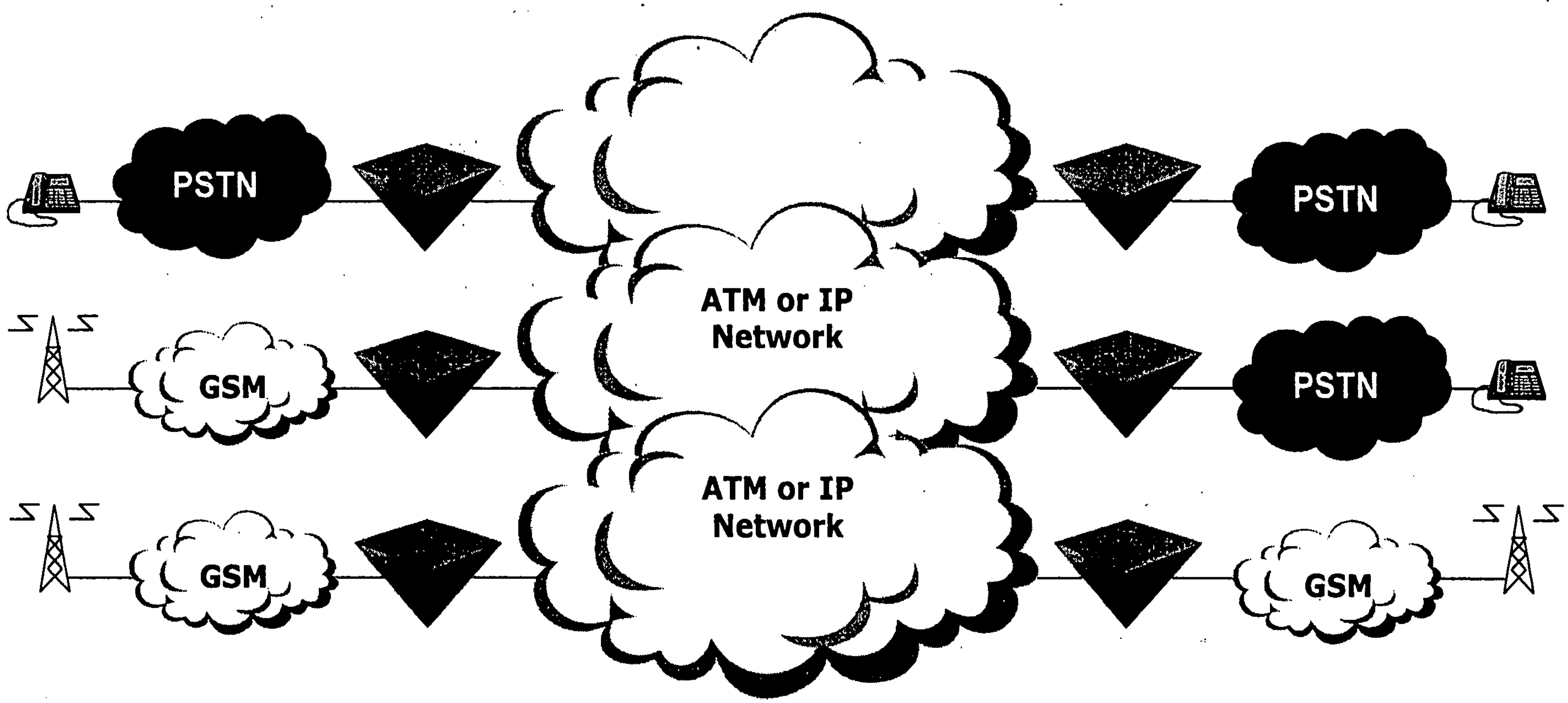


Fig. 7

POTS to POTS (P-P)						
Nat'l		Int'l 0 DCME		Int'l 1 DCME		Int'l 2 DCME
87.8		[illegible]		76.8		66.6
POTS to Mobile (P-M)						
Nat'l		Int'l 0 DCME		Int'l 1 DCME		Int'l 2 DCME
81.7		70.6		59.8		49.4
Mobile to Mobile (M-M)						
Nat'l		Int'l 0 DCME		Int'l 1 DCME		Int'l 2 DCME
[illegible]		58.3		[illegible]		39

R	USER SATISFACTION
100	
94	Very Satisfied
90	
	Satisfied
80	
70	
	Many Users Dissatisfied
60	
	Nearly All Users Dissatisfied
50	
	Not Recommended
0	

Limit of acceptability - a hard threshold

Mobile is GSM EFR.
POTS is modelled for an analogue set.
Nat'l = 8000km, Int'l = 27500km.

Fig. 8

What reference calls will be the most demanding quality measure?

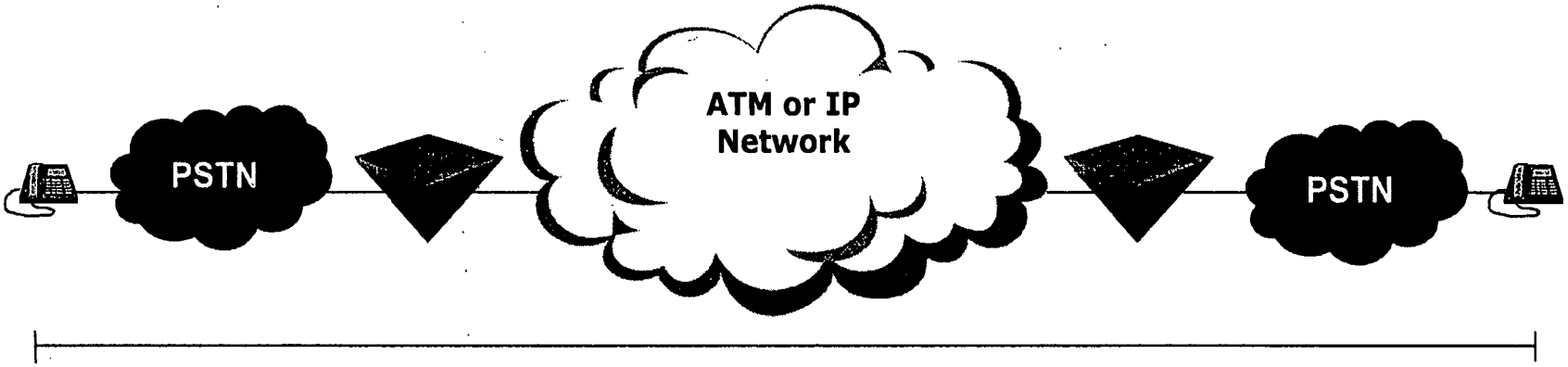


Fig. 9

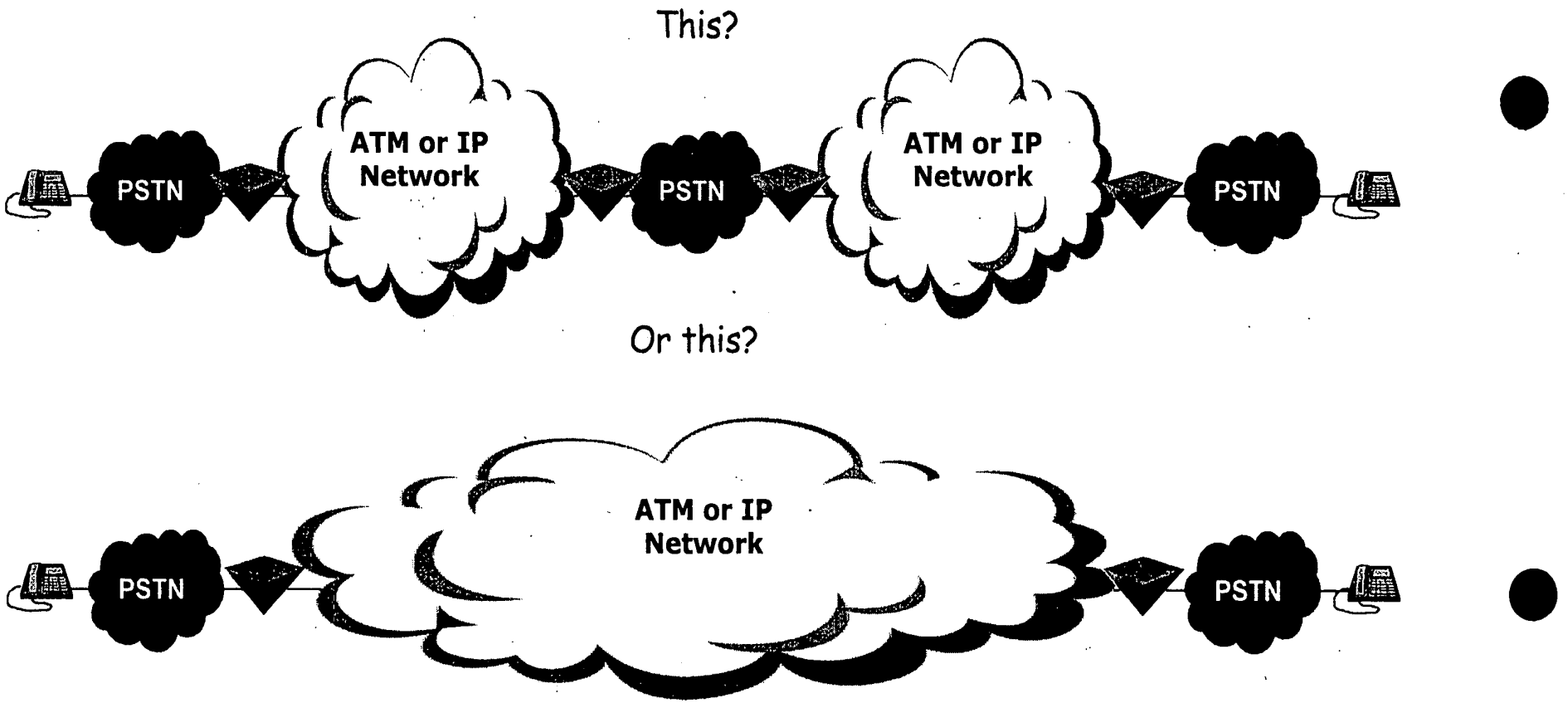
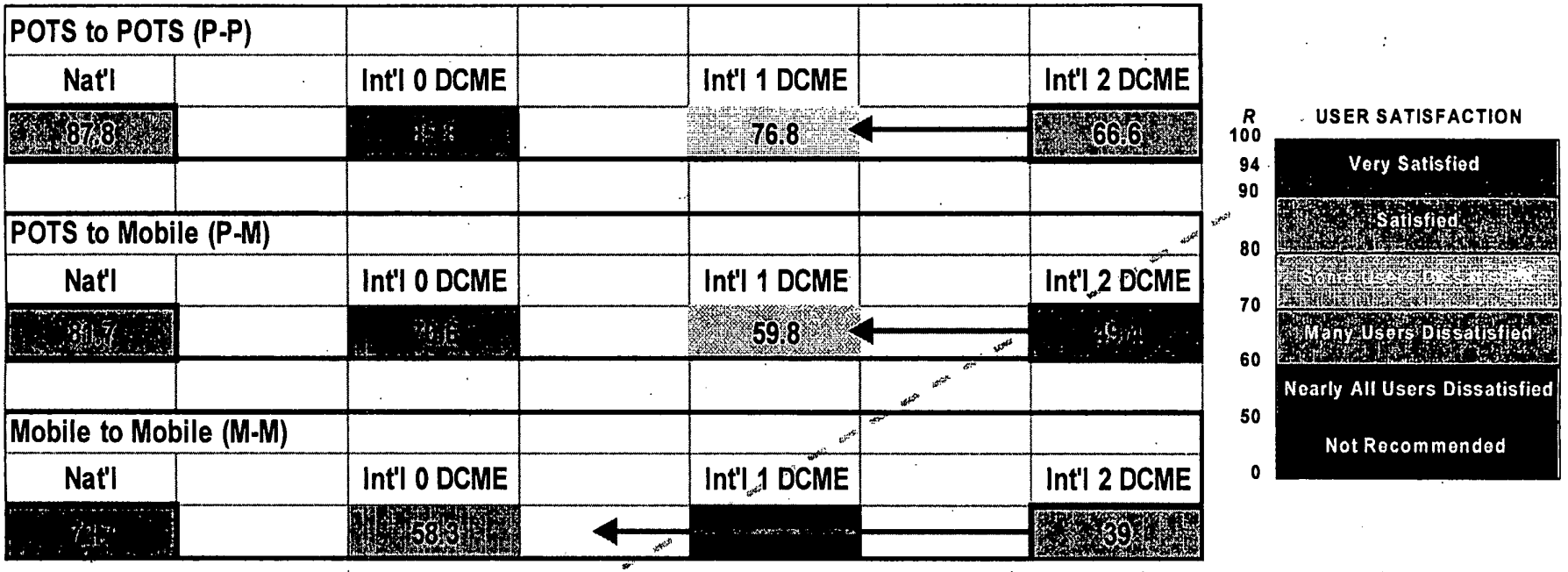

This?
PSTN
ATM or IP Network
PSTN
ATM or IP Network
PSTN
Or this?
PSTN
ATM or IP Network
PSTN

Fig. 10

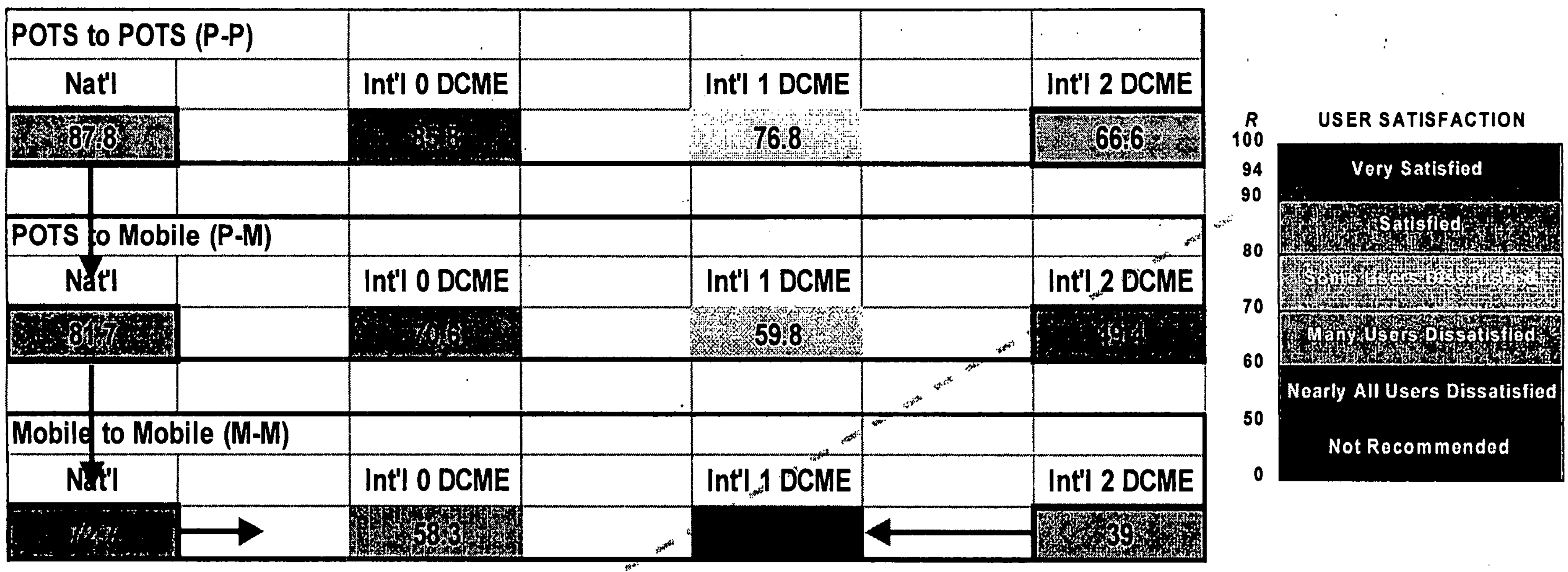


Limit of acceptability - a hard threshold

Mobile is GSM EFR, POTS is modelled for an analogue set. Nat'l = 8000km, Int'l = 27500km.

(*5R = 0.2 MOS over most of the linear range considered in the statistical noise by many practitioners.)

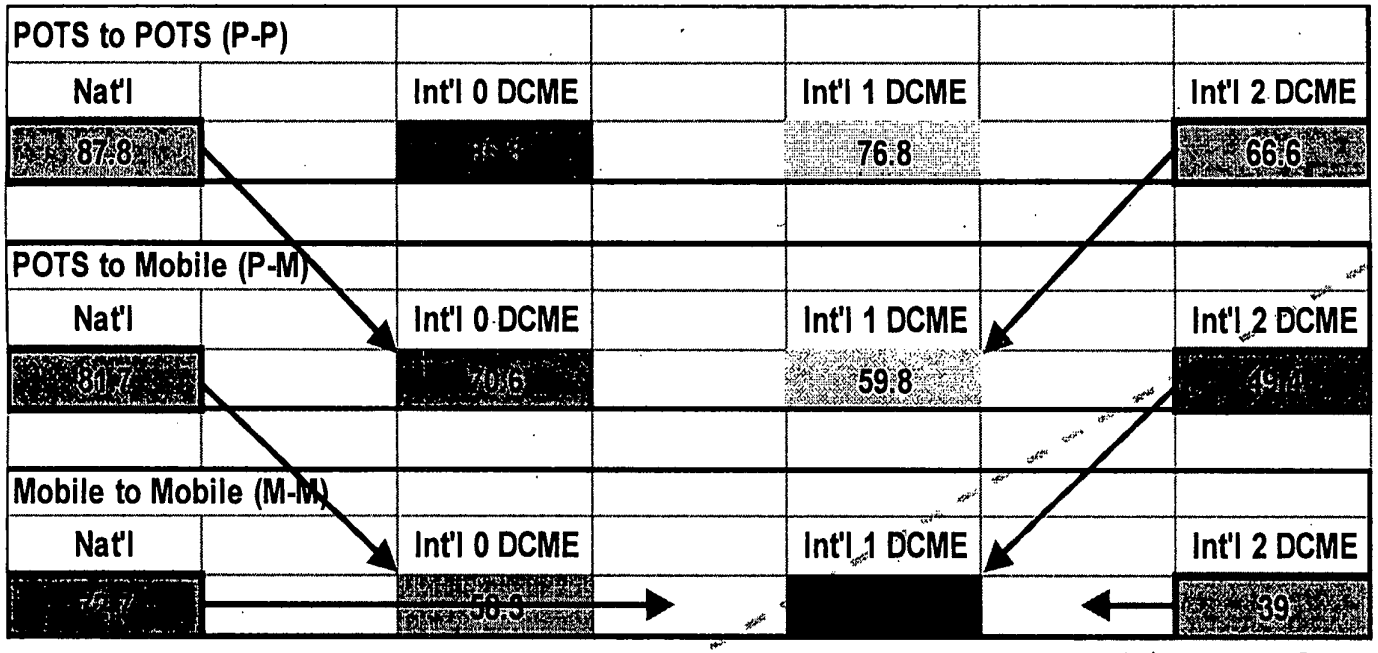
Fig. 11

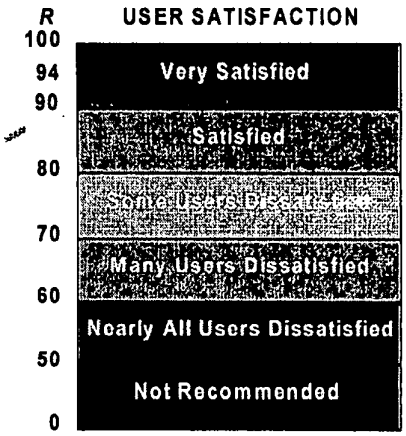


Limit of acceptability - a hard threshold

Mobile is GSM EFR, POTS is modelled for an analogue set. Nat'l = 8000km, Int'l = 27500km.

Fig. 12

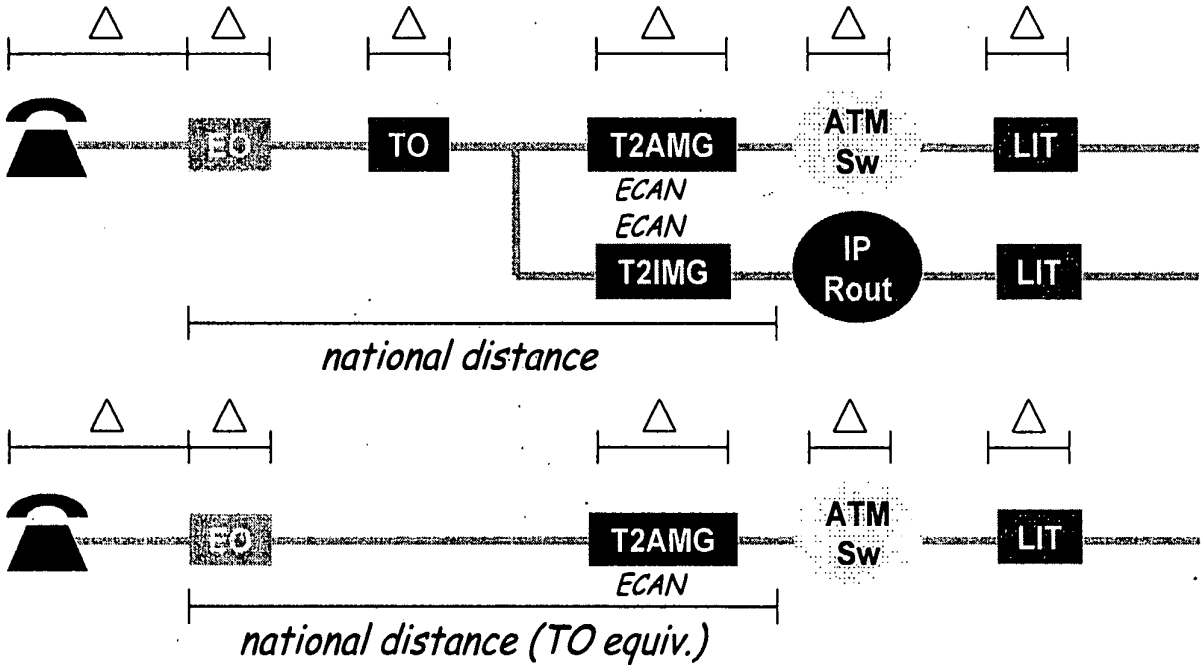




Limit of acceptability - a hard threshold

Mobile is GSM EFR, POTS is modelled for an analogue set. Nat'l = 8000km, Int'l = 27500km.

Fig. 13



EO - End Office
TO - Tandem Office
T2AMG - TDM trunk to AAL-2 MG
T2IMG - TDM trunk to VoIP MG
LIT - Lawful Intercept Tap

Fig. 14

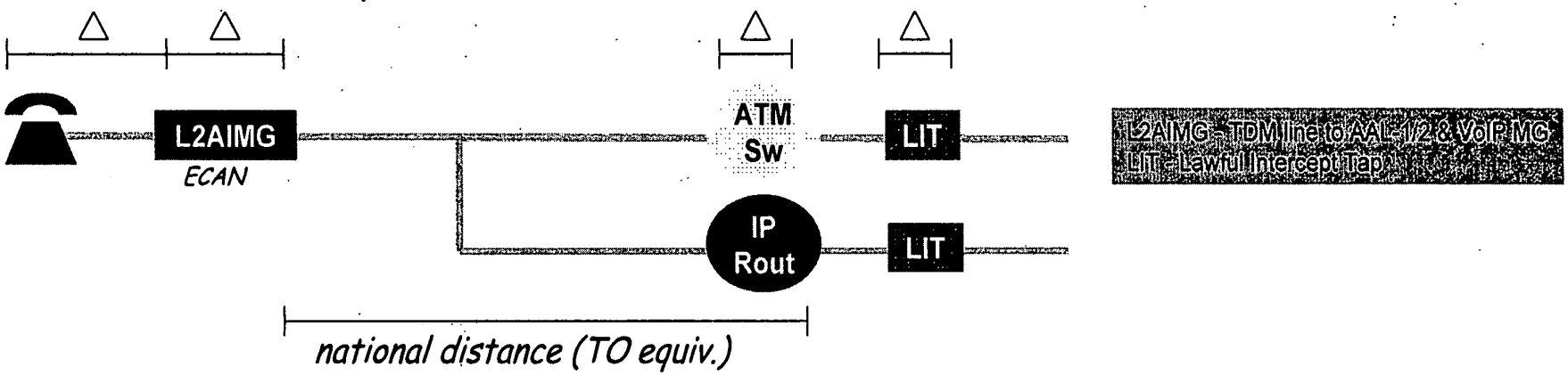


Fig. 15

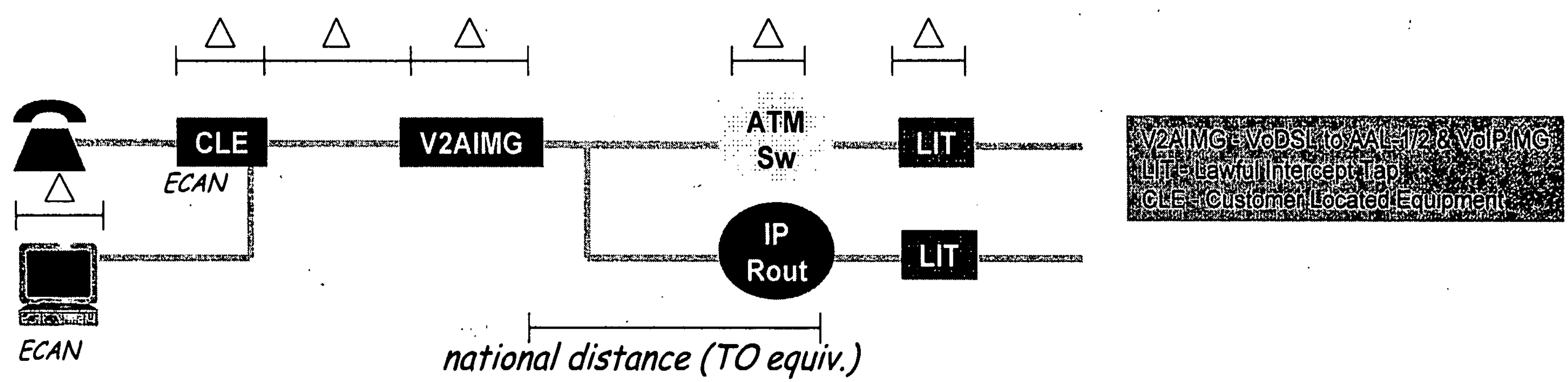

CLE
ECAN
V2AIMG
ATM
Sw
IP
Rout
LIT
LIT
ECAN
national distance (TO equiv.)
V2AIMG - VoDSL to AAL-1/2 & VoIP MG
LIT - Lawful Intercept Tap
CLE - Customer Located Equipment

Fig. 16

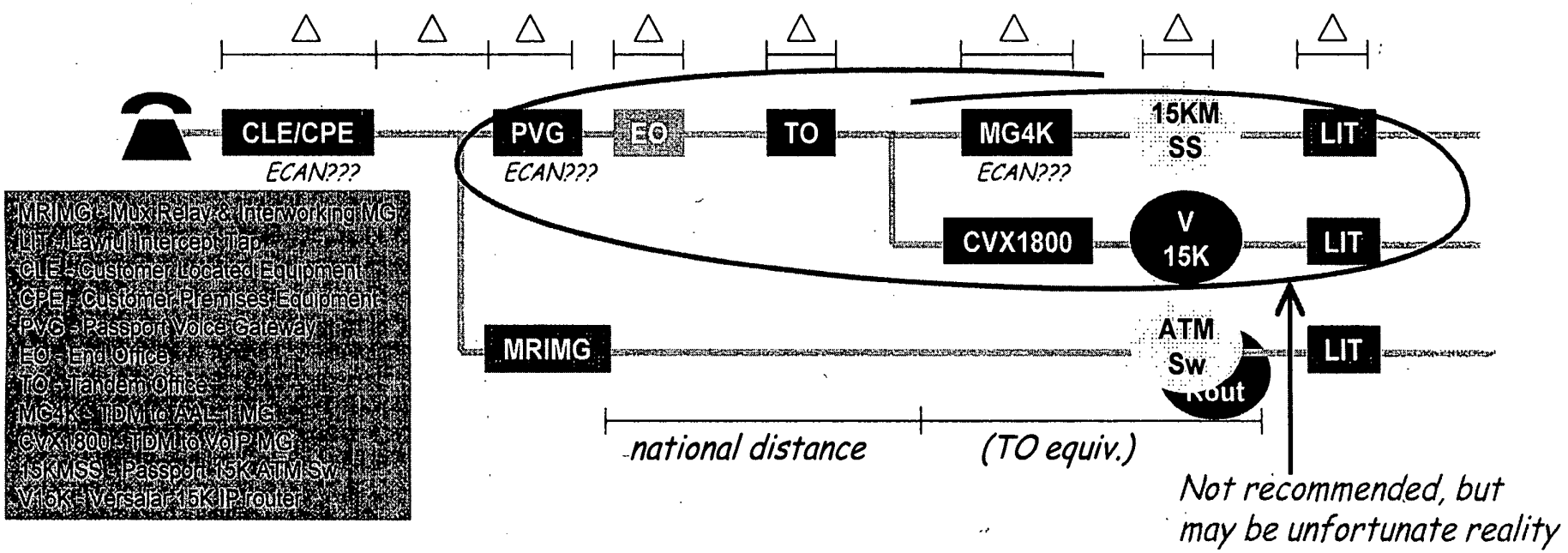
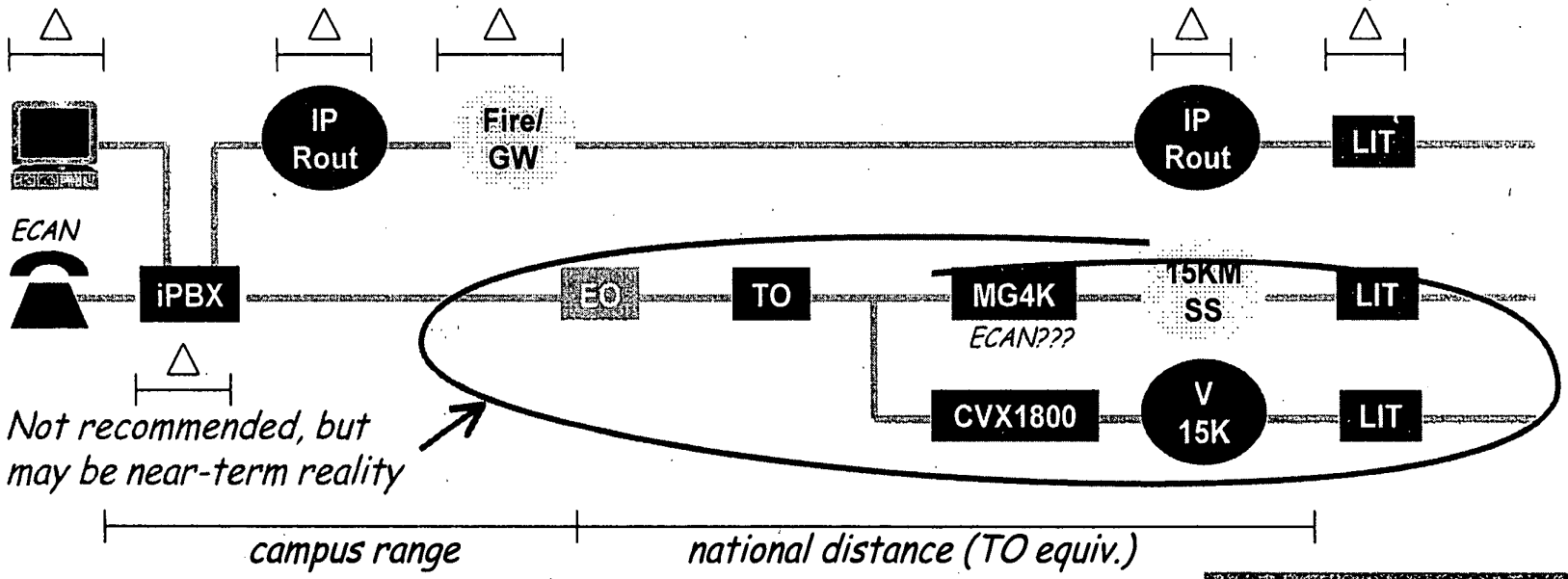

CLE/CPE
ECAN???
PVG
ECAN???
EO
TO
MG4K
ECAN???
15KM
SS
LIT
CVX1800
V
15K
LIT
MRIMG
ATM
Sw
Rout
LIT
national distance
(TO equiv.)
Not recommended, but
may be unfortunate reality
MRIMG - Mux Relay & Interworking MG
LIT - Lawful Intercept Tap
CLE - Customer Located Equipment
CPE - Customer Premises Equipment
PVG - Passport Voice Gateway
EO - End Office
TO - Tandem Office
MG4K - TDM to AAL-1 MG
CVX1800 - TDM to VoIP MG
15KMSS - Passport 15K ATM Sw
V15K - Versalar 15K IP router

Fig. 17



MRIMG - Mux Relay & Interworking MG
LIT - Lawful Intercept Tap
CLE - Customer Located Equipment
CPE - Customer Premises Equipment
PVG - Passport Voice Gateway
EO - End Office
TO - Tandem Office
MG4K - TDM to AAL-1 MG
CVX1800 - TDM to VoIP MG
15KMSS - Passport 15K ATM Sw
V15K - Versalar 15K IP router

Fig. 18

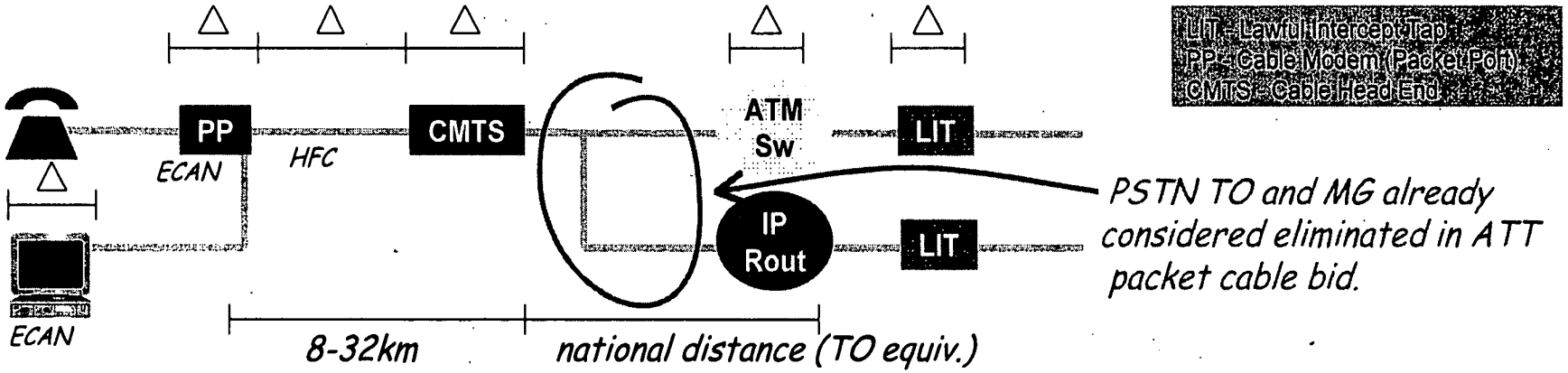

LIT - Lawful Intercept Tap
PP - Cable Modem (Packet Port)
CMTS - Cable Head End
PP
ECAN
HFC
CMTS
ATM
Sw
LIT
IP
Rout
LIT
ECAN
PSTN TO and MG already considered eliminated in ATT packet cable bid.
8-32km
national distance (TO equiv.)

Fig. 19

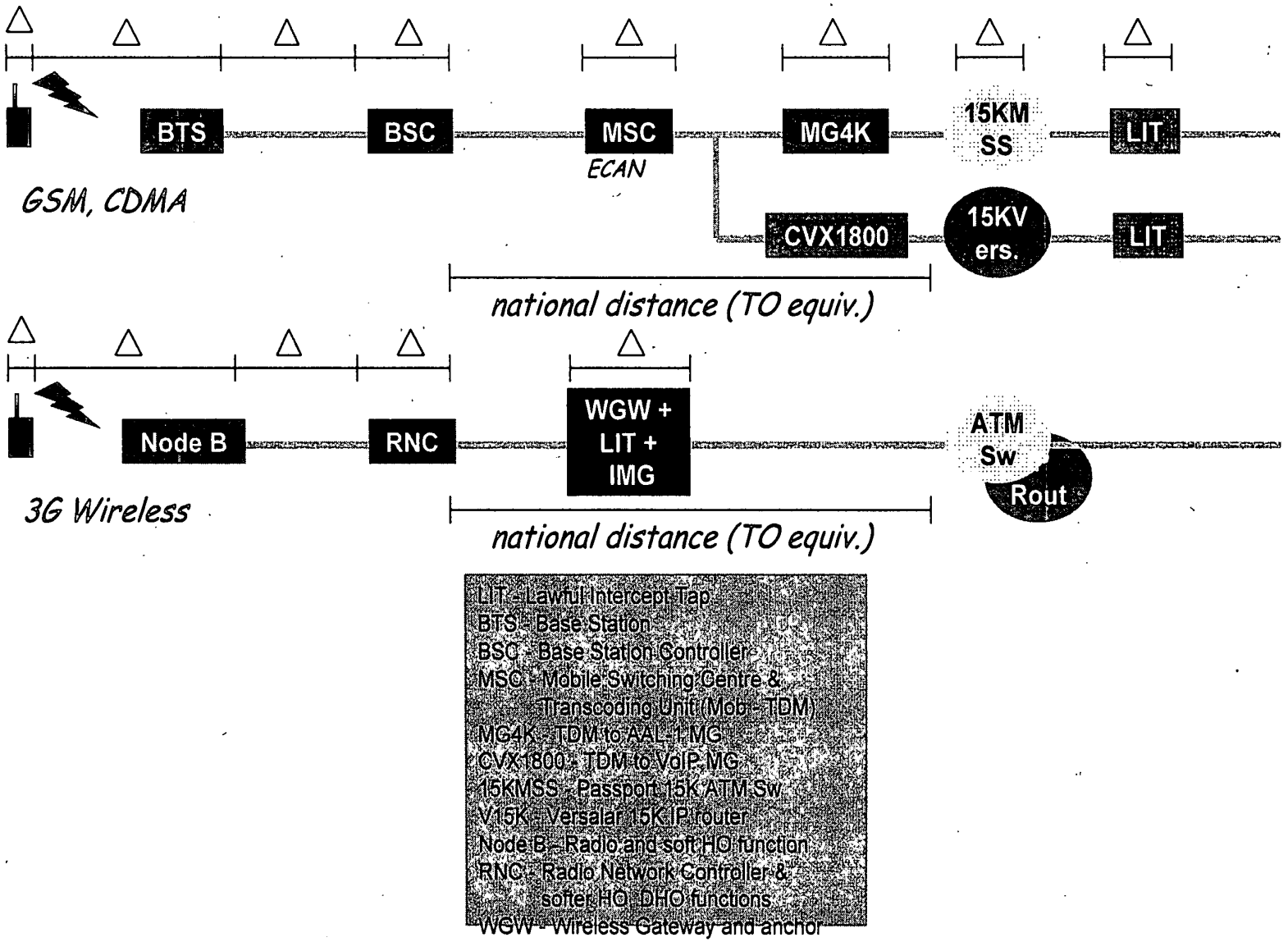

BTS
BSC
MSC
ECAN
MG4K
15KM
SS
LIT
GSM, CDMA
CVX1800
15KV
ers.
LIT
national distance (TO equiv.)
Node B
RNC
WGW +
LIT +
IMG
ATM
Sw
Rout
3G Wireless
national distance (TO equiv.)
LIT - Lawful Intercept Tap
BTS - Base Station
BSC - Base Station Controller
MSC - Mobile Switching Centre &
Transcoding Unit (Mobi - TDM)
MG4K - TDM to AAL-1 MG
CVX1800 - TDM to VoIP MG
15KMSS - Passport 15K ATM Sw
V15K - Versalar 15K IP router
Node B - Radio and soft HO function
RNC - Radio Network Controller &
softer HO, DHO functions
WGW - Wireless Gateway and anchor

Fig. 20

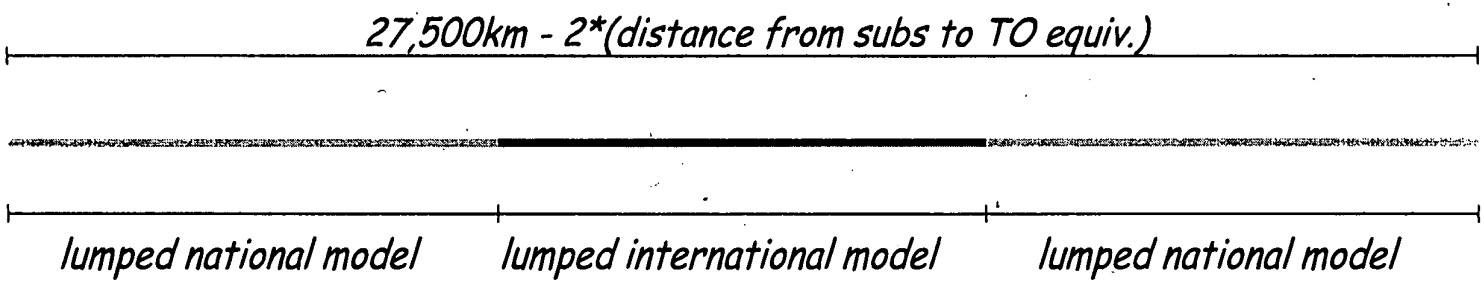
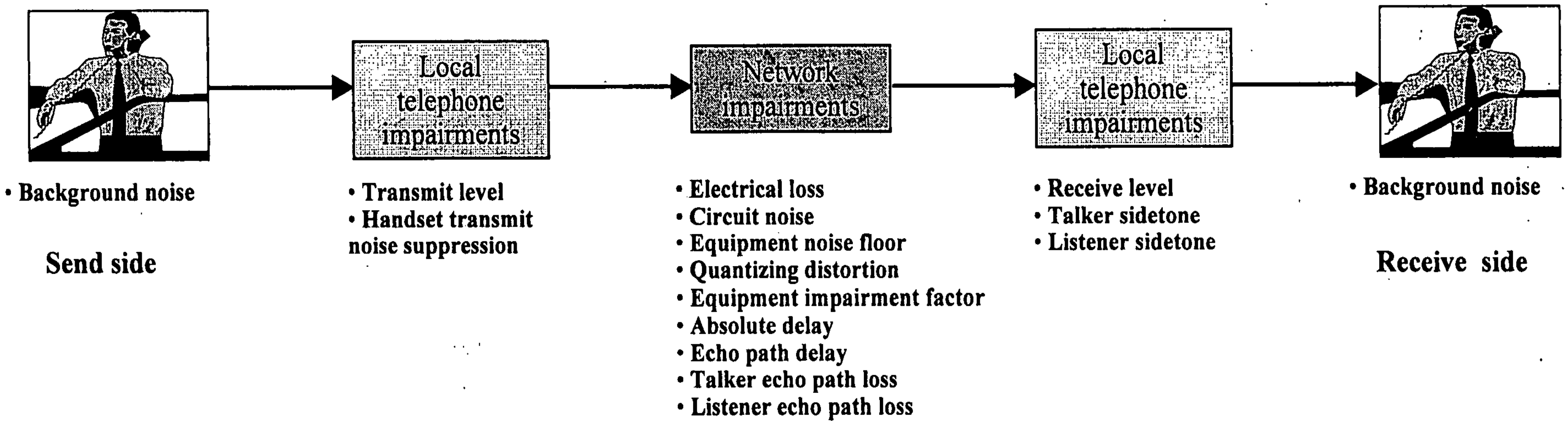


Fig. 21



The E-model calculates a Transmission Rating Factor *R*, given by

$$R = R_o - I_s - I_d - I_e + A$$

Fig. 22

E-Model Parameter Default Values

Parameter	Units	Value
SLR (Send Loudness Rating)	dB	8
RLR (Receive Loudness Rating)	dB	2
STMR (Sidetone Masking Rating)	dB	15
LSTR (Listener Sidetone Rating)	dB	18
OLR (Overall Loudness Rating)	dB	10
TELR (Talker Echo Loudness Rating)	dB	65
WEPL (Weighted Echo Path Loss)	dB	110
T (Mean Intrinsic One-Way Delay)	msec	0
Ta (Absolute Delay)	msec	0
Tr (Round-Trip Delay)	msec	0
QDU (Quantization Distortion Units)	-	1
Ie (Equipment Impairment Factor)	-	0
A (Expectation Factor)	-	0
Ds (Handset Shape Factor – Send Side)	-	3
Dr (Handset Shape Factor – Receive Side)	-	3
Ps (Room Noise at the Send side)	dB(A)	35
Pr (Room Noise at the Receive side)	dB(A)	35
Nc (Circuit Noise referred to 0 dBr-point)	dBm0p	-70
Nfor (Noise Floor at the Receive Side)	dBmp	-64

Fig. 23

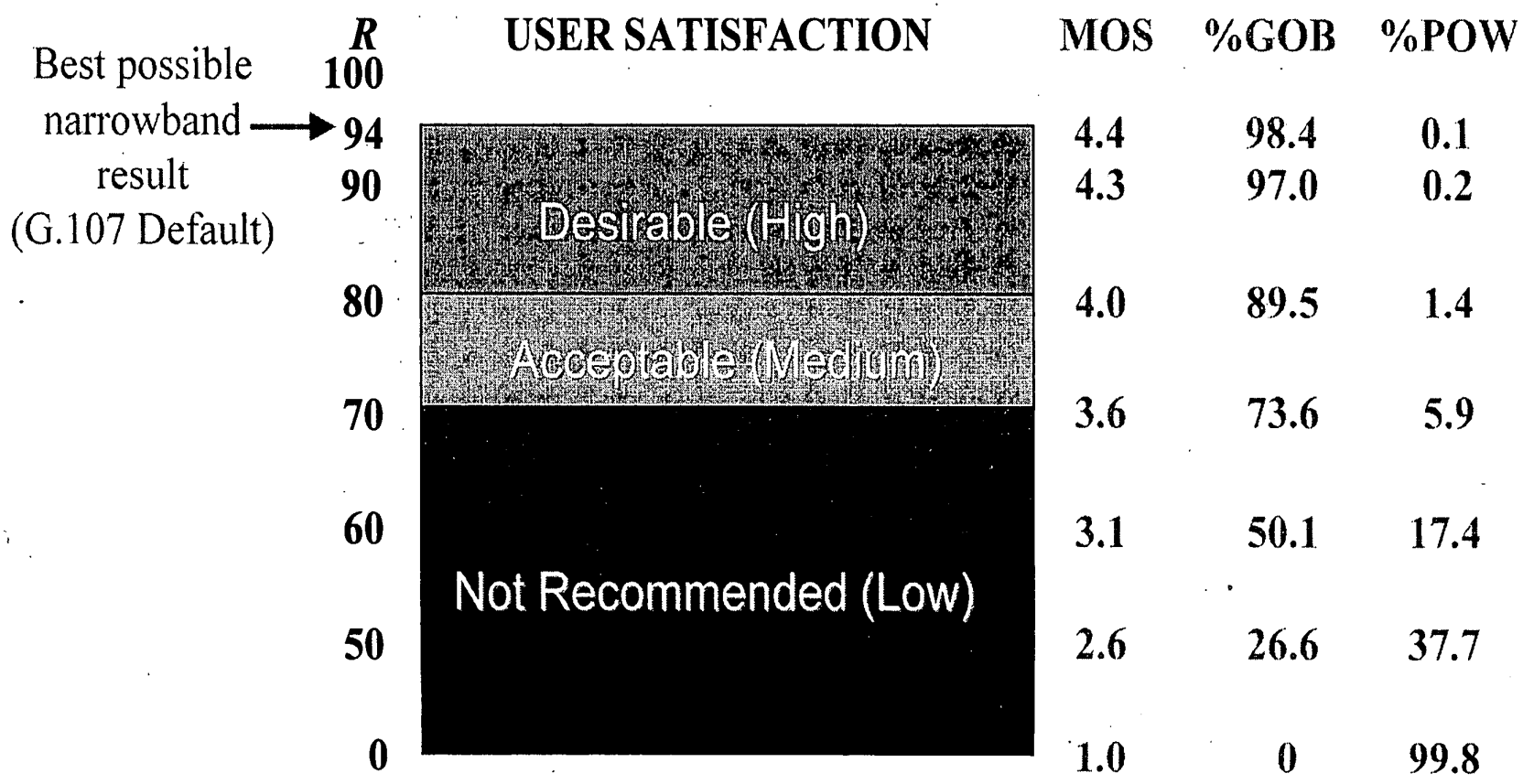

Best possible narrowband result (G.107 Default)
R
USER SATISFACTION
MOS
%GOB
%POW
100
94
90
80
70
60
50
0
Desirable (High)
Acceptable (Medium)
Not Recommended (Low)
4.4
98.4
0.1
4.3
97.0
0.2
4.0
89.5
1.4
3.6
73.6
5.9
3.1
50.1
17.4
2.6
26.6
37.7
1.0
0
99.8

Fig. 24

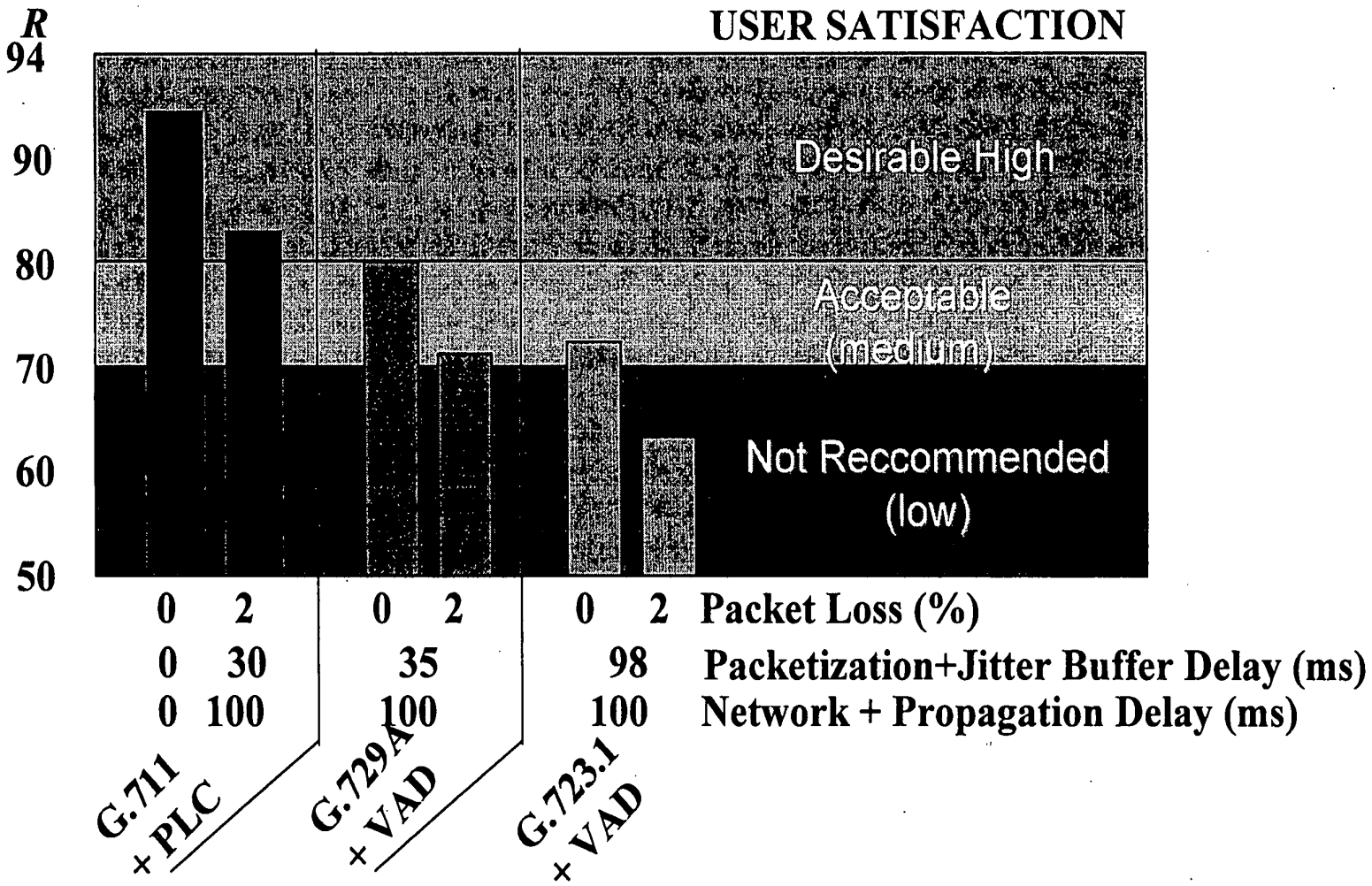

R
USER SATISFACTION
94
90
80
70
60
50
Desirable High
Acceptable (medium)
Not Reccommended (low)
0 2 0 2 0 2 Packet Loss (%)
0 30 35 98 Packetization+Jitter Buffer Delay (ms)
0 100 100 100 Network + Propagation Delay (ms)
G.711 + PLC
G.729A + VAD
G.723.1 + VAD

Fig. 25

	le for E-Model Calculations								
	G.711 [Ref.10] [Notes 2, 3]	G.711 [Notes 1, 2, 3]	G.711 [Notes 1, 2, 3]	G.711 [Notes 1, 2, 3, 4]	G.729A [Notes 1, 3]	G.729A [Ref.10] [Note 3]	G.729A [Notes 1, 3]	G.729A [Notes 1, 3]	G.726 32kb/s note [5]
Frame Size (ms)	.125	.125	.125	.125	10	10	10	10	.125
Packet Payload (ms)	10	20	30	40	10	20	30	40	20
Packet Loss (%)									
0	**0**	0	0	0	11	**11**	11	11	7
1	**5**	8	10	13	13	**15**	17	19	**N/A**
2	7	13	16	19	16	**19**	21	24	**N/A**
3	**10**	19	22	24	19	**23**	25	28	**N/A**
4	**12.5***	22	26	28	22	**26**	29	32	**N/A**
5	**15**	25	30	32	25	**29***	32	35	**N/A**

Notes:

1) In the absence of any supporting documentation, these are arbitrary values
2) All G.711 vocoders are assumed to have PLC (Packet Loss Concealment) algorithms
3) Impairment factors apply for random packet loss conditions
4) This is the current capability of the i2004 (in the absence of any download instructions to achieve smaller frame size)
5) There is no PLC algorithm for G.726, therefore its deployment might be limited in lossy network
6) Interpolated values

Fig. 26

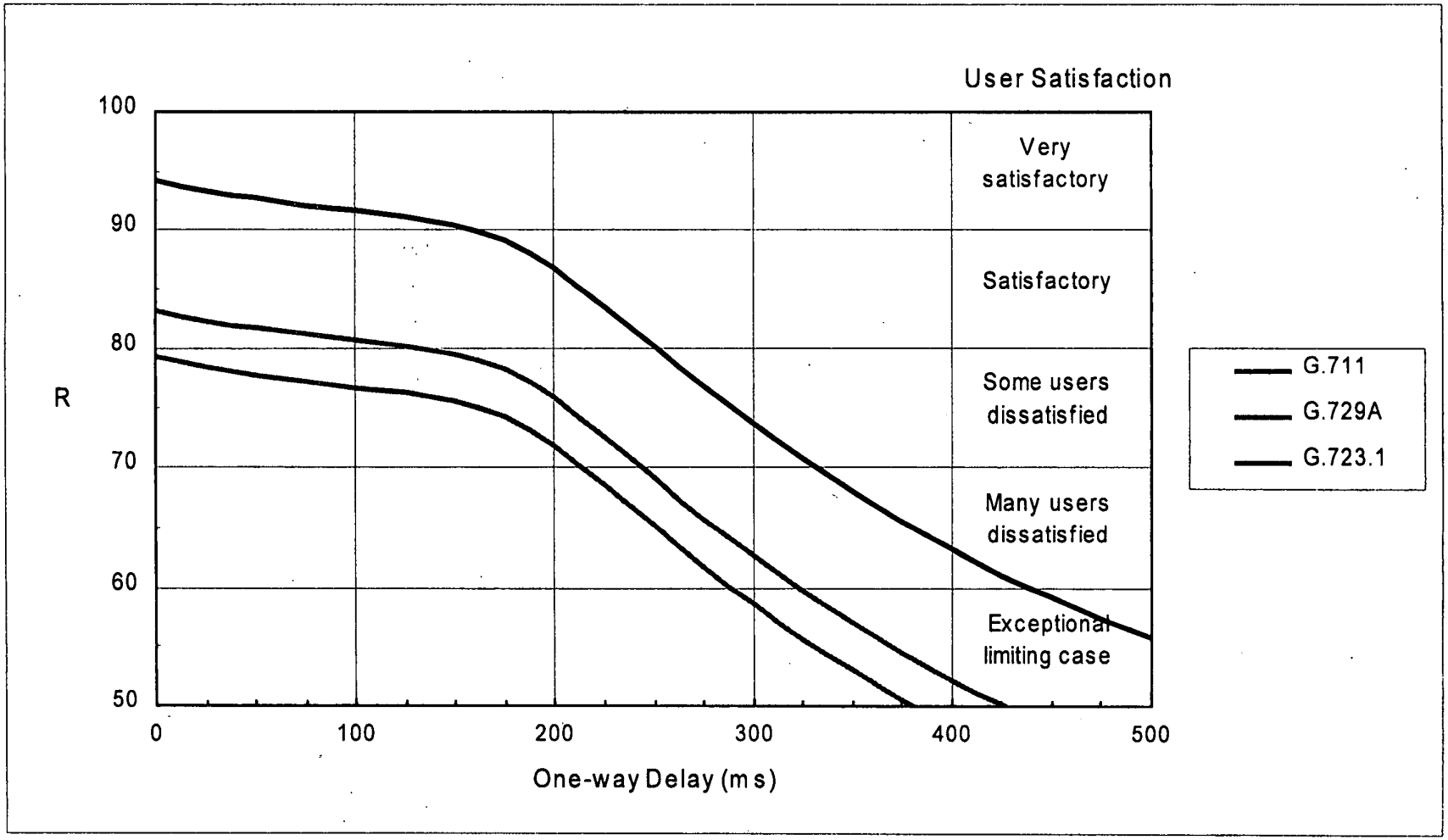

User Satisfaction
100
90
80
70
60
50
R
0
100
200
300
400
500
One-way Delay (ms)
Very satisfactory
Satisfactory
Some users dissatisfied
Many users dissatisfied
Exceptional limiting case
G.711
G.729A
G.723.1

Fig. 27

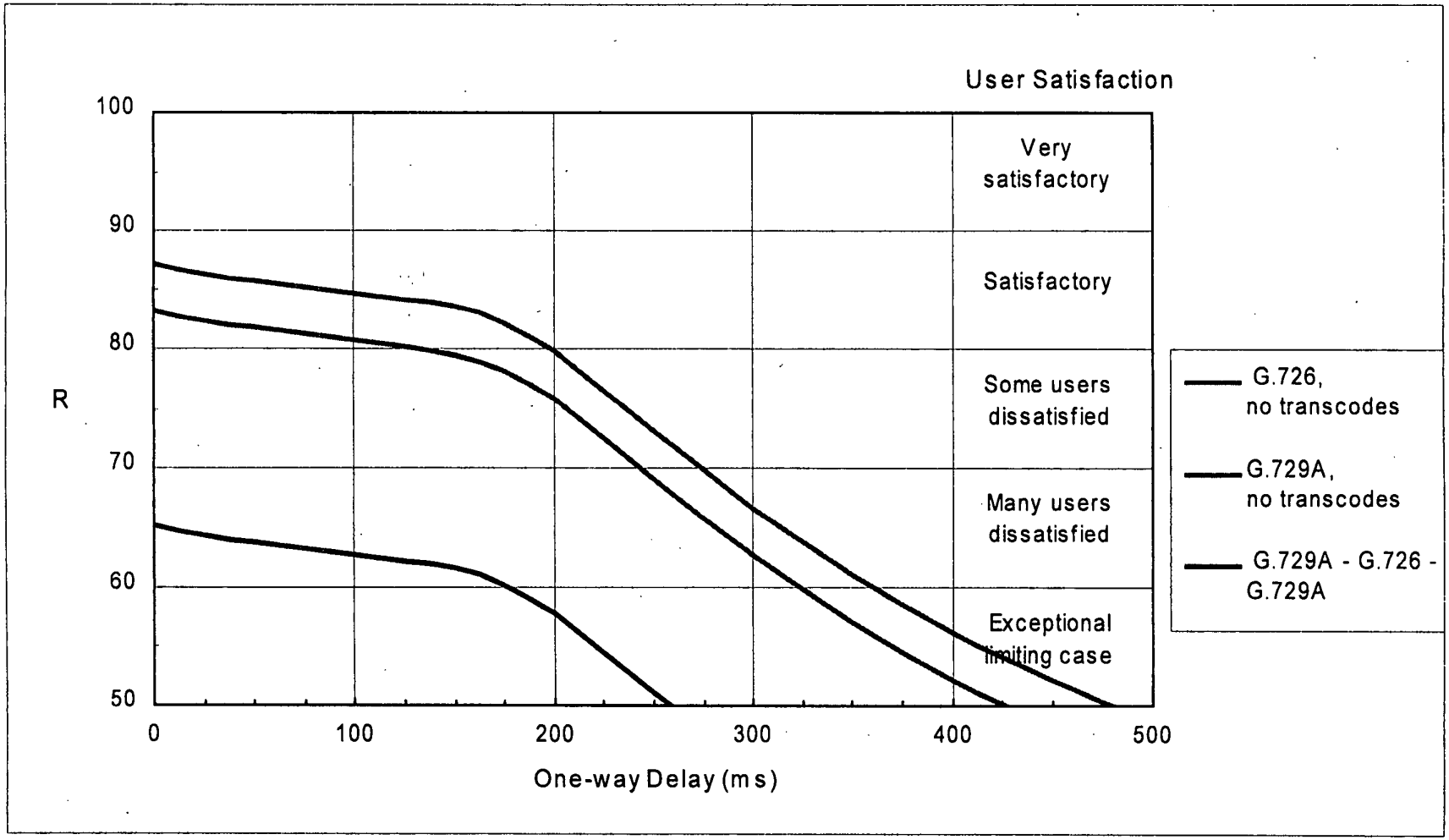


Fig. 28

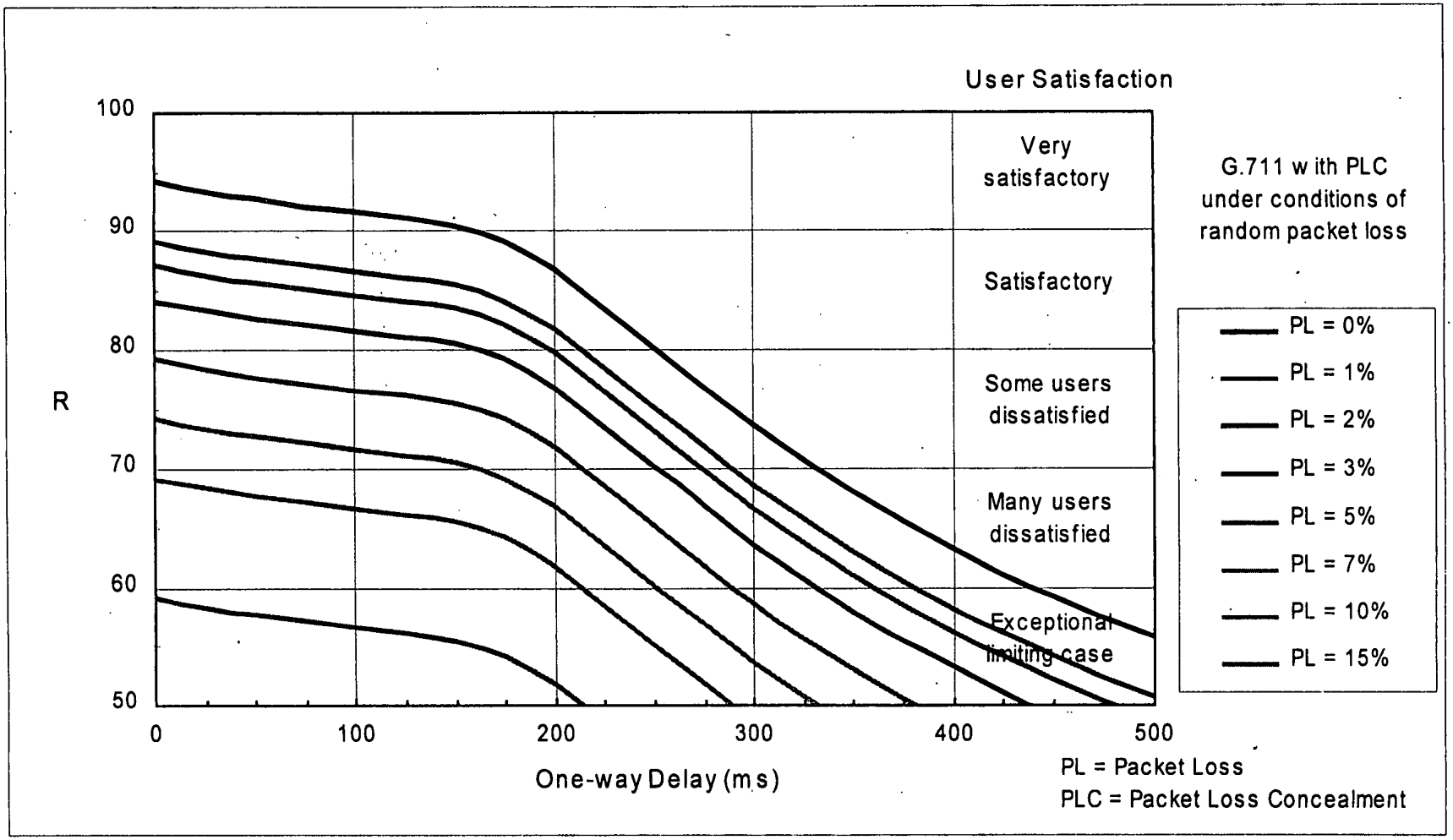

User Satisfaction
100
90
80
70
60
50
R
0
100
200
300
400
500
One-way Delay (ms)
Very satisfactory
Satisfactory
Some users dissatisfied
Many users dissatisfied
Exceptional limiting case
G.711 with PLC under conditions of random packet loss
PL = 0%
PL = 1%
PL = 2%
PL = 3%
PL = 5%
PL = 7%
PL = 10%
PL = 15%
PL = Packet Loss
PLC = Packet Loss Concealment

Fig. 29

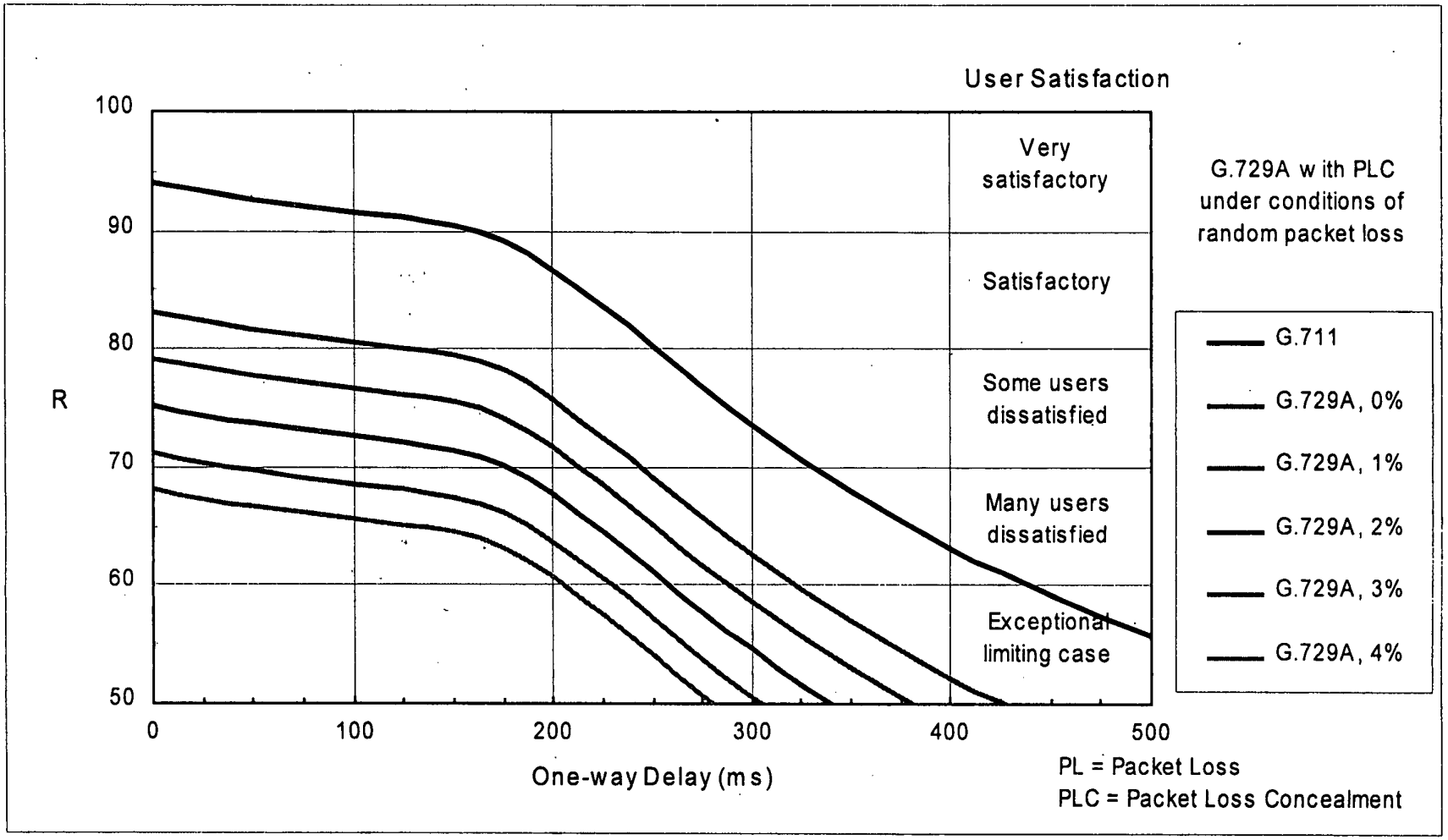

User Satisfaction
100
90
80
70
60
50
R
0
100
200
300
400
500
One-way Delay (ms)
Very satisfactory
Satisfactory
Some users dissatisfied
Many users dissatisfied
Exceptional limiting case
G.729A with PLC under conditions of random packet loss
G.711
G.729A, 0%
G.729A, 1%
G.729A, 2%
G.729A, 3%
G.729A, 4%
PL = Packet Loss
PLC = Packet Loss Concealment

Fig. 30

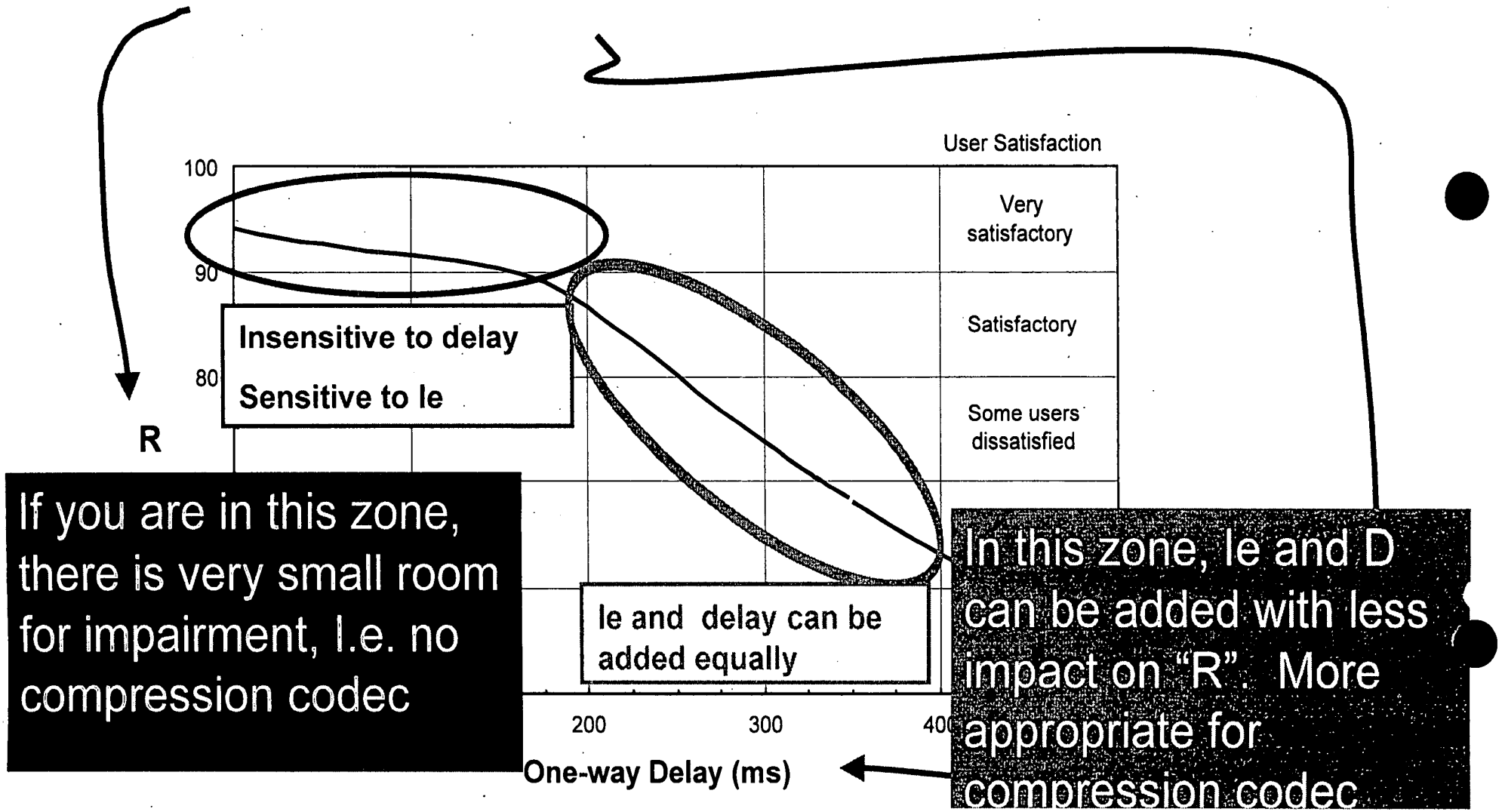
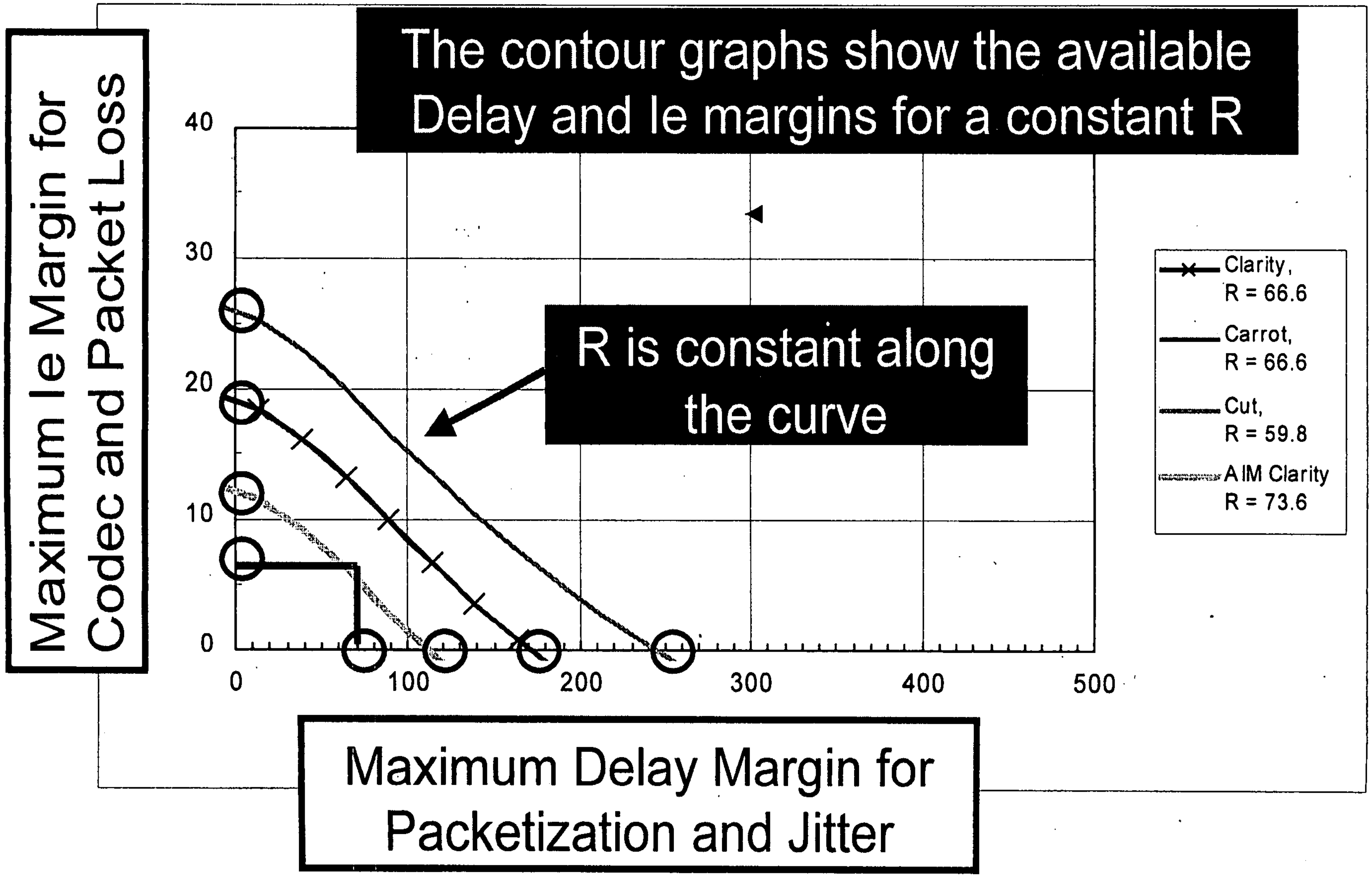

User Satisfaction
100
90
80
Very satisfactory
Satisfactory
Some users dissatisfied
Insensitive to delay
Sensitive to Ie
R
Ie and delay can be added equally
200
300
One-way Delay (ms)
If you are in this zone, there is very small room for impairment, I.e. no compression codec
In this zone, Ie and D can be added with less impact on "R". More appropriate for compression codec

Fig. 31



The contour graphs show the available Delay and Ie margins for a constant R
R is constant along the curve
Maximum Ie Margin for Codec and Packet Loss
Maximum Delay Margin for Packetization and Jitter
0
10
20
30
40
0
100
200
300
400
500
Clarity, R = 66.6
Carrot, R = 66.6
Cut, R = 59.8
AIM Clarity R = 73.6

Fig. 32

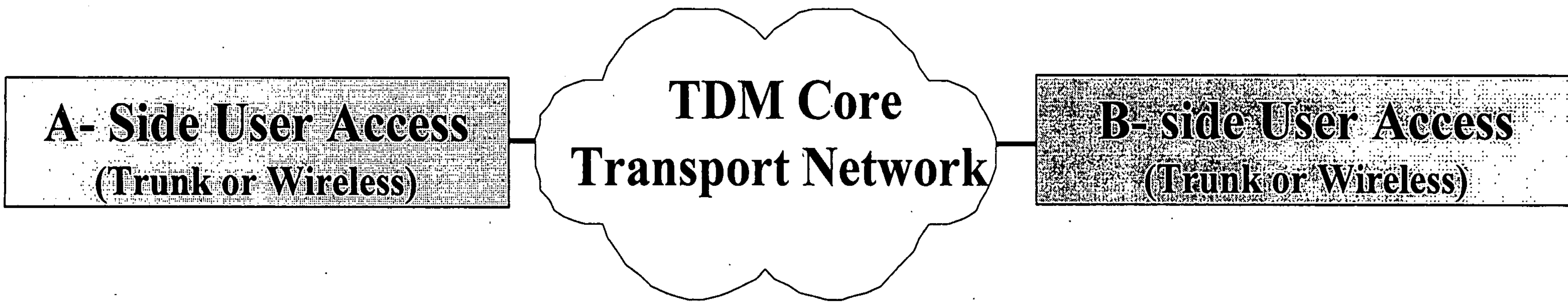
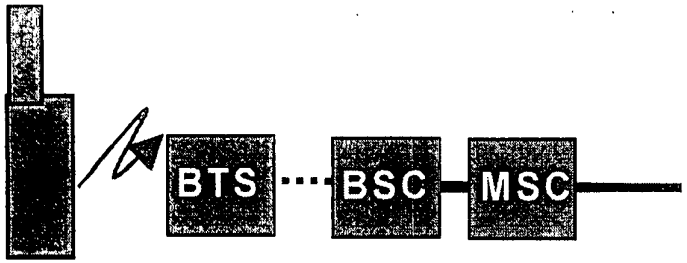

A- Side User Access
(Trunk or Wireless)
TDM Core
Transport Network
B- side User Access
(Trunk or Wireless)

Fig. 33

Title	Abbreviation (Default)	E-Model Input
		POTS
Electric Circuit Noise (at 0 dBr)	Nc (-70 dBmP)	
Room Noise	Po (35 dBA)	35
Send Loudness Rating	SLR (8 dB)	11
Receive Loudness Rating	RLR (2 dB)	3
D-factor	D (3)	3
Noise Floor	Nfor (-64 dBm0)	-64
Sidetone Masking Rating	STMR (15)	15
Equipment Impairment Factor	Ie (0)	0
Expectation (Advantage) Factor	A (0)	0
Mean Intrinsic One-Way Delay (upper)	Tu (0 ms)	0
Mean Intrinsic One-Way Delay (lower)	Tl (0 ms)	0
Mean Intrinsic One-Way Delay	Tul (0 ms)	0
Electrical Loss (upper)	Lu (dB)	0
Electrical Loss (lower)	Ll (dB)	0
Electrical Loss (upper = lower)	Lul (dB)	0
Quantizing Distortion Units (upper)	qduu (1) [Note 1]	0
Quantizing Distortion Units (lower)	qdul (1) [Note 1]	0
Echo Return Loss	ERL (dB)	17

Fig. 34



BTS: Base Station
BSC: Base Station Controller
MSC: Mobile Switching Center

PSTN Wireless Access Delay, loss and Impairment Summary		
	Uplink	Downlink
Mobile Switching Center (MSC) (ms)	1	2
Base Station Controller (BSC) (ms)	2.5	40
Base Station (BTS) (ms)	15.8	40.8
Mobile Set (MS) (ms)	72.1	14.3
PSTN Wireless Access Delay (ms)	**91.40**	**97.10**
Impairment Factor (Ie)	**5**	**5**

Fig. 35

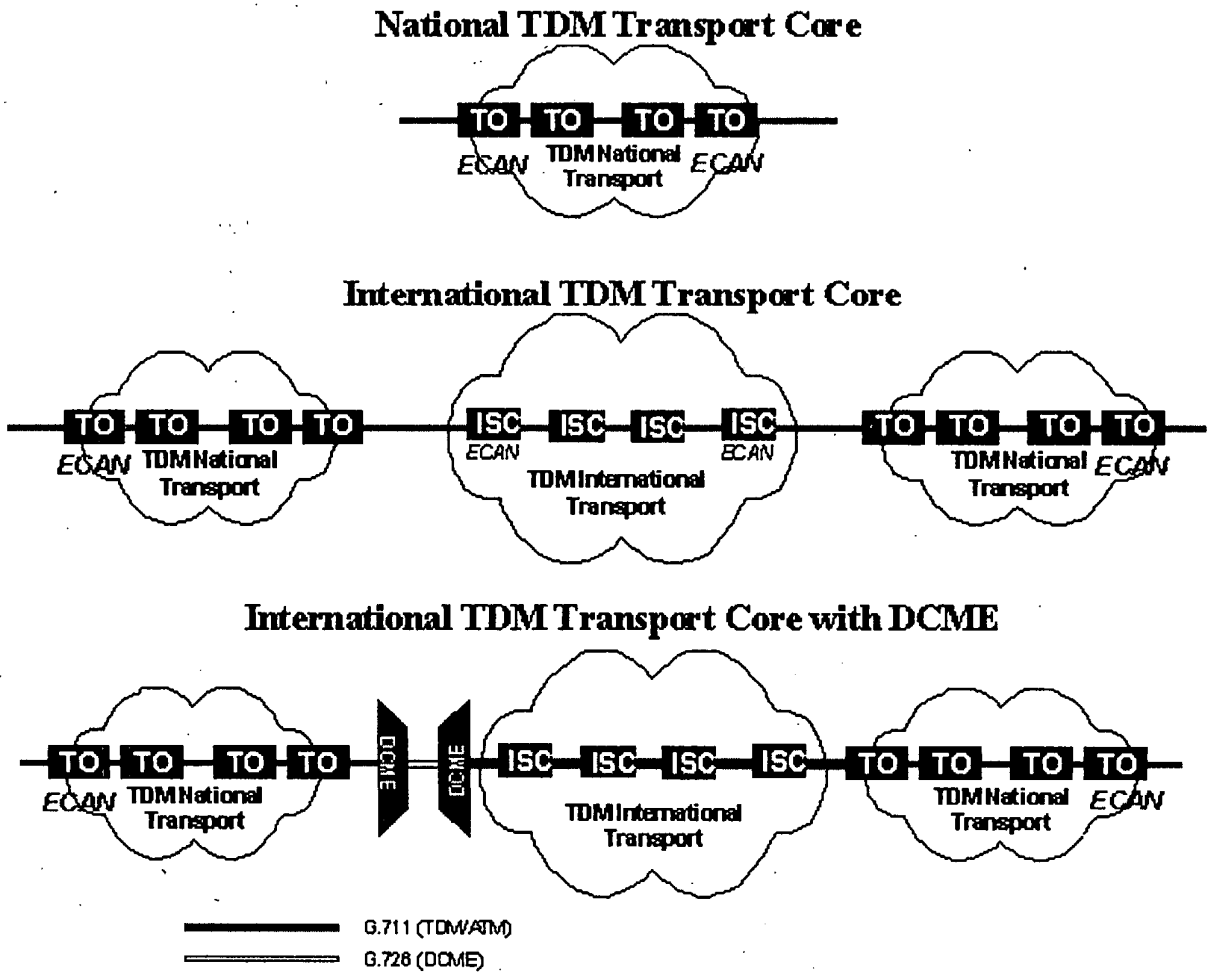
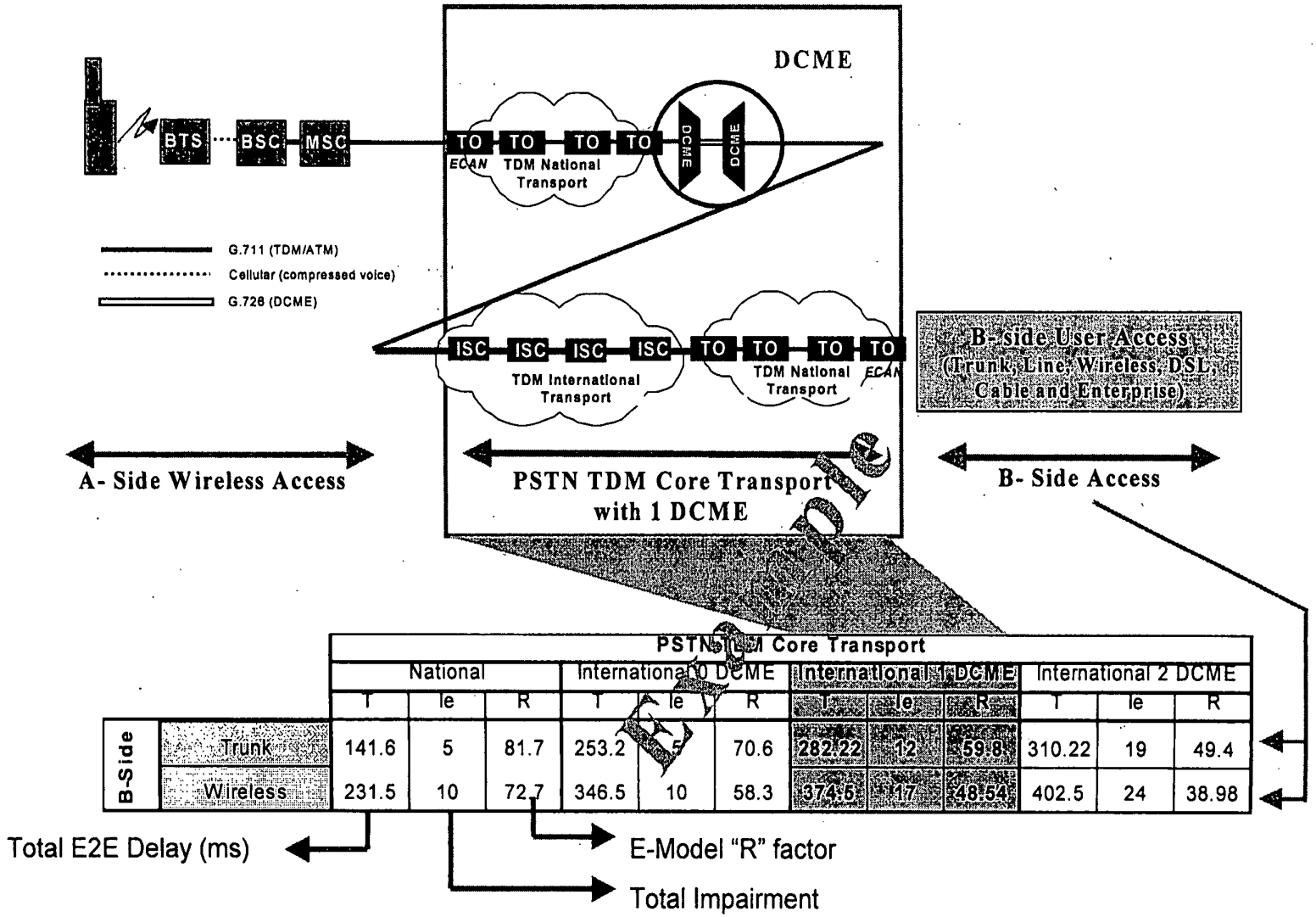

National TDM Transport Core
TO
TO
TO
TO
ECAN
TDM National Transport
ECAN
International TDM Transport Core
TO
TO
TO
TO
ECAN
TDM National Transport
ISC
ISC
ISC
ISC
ECAN
ECAN
TDM International Transport
TO
TO
TO
TO
TDM National Transport
ECAN
International TDM Transport Core with DCME
TO
TO
TO
TO
ECAN
TDM National Transport
DCME
DCME
ISC
ISC
ISC
ISC
TDM International Transport
TO
TO
TO
TO
TDM National Transport
ECAN
G.711 (TDM/ATM)
G.726 (DCME)

Fig. 36

TDM Core Transport	National (8000km)	International (connection Length 27500 km)			
		0 DCME	1 DCME	2 DCME	3 DCME
National Transmission Time	43	43	43	43	43
T2DCME (G.711/G.726 Conversion+DSI) (ms)	-	0	26	52	78
DCME2T (G.726/G.711 Conversion) (ms)	-	0	2	4	6
International Transmission Time (ms	-	72	72	72	72
National Transmission Time	-	43	43	43	43
Total one-way delay (ms)	43	158	186	214	242
Impairment Factor (Ie)	0	0	7	14	21

Fig. 37



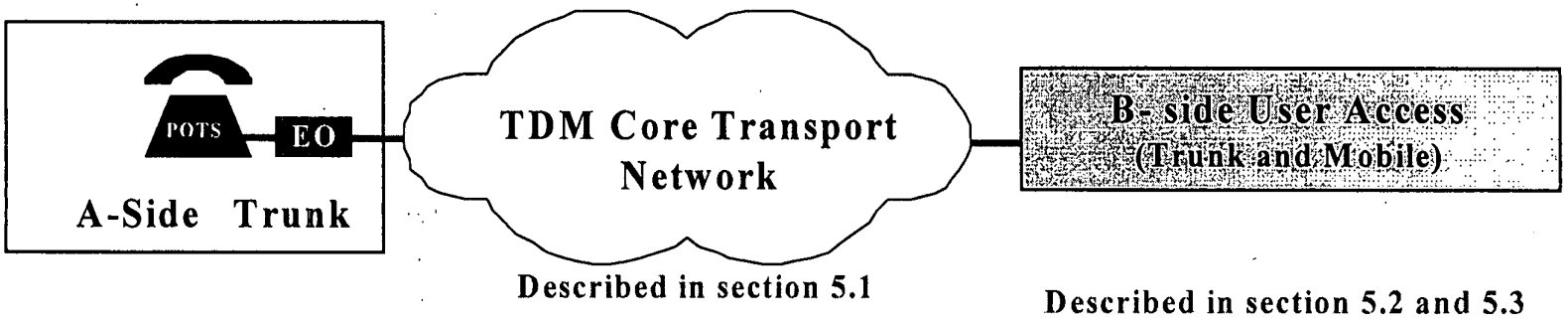
		PSTN TDM Core Transport											
		National			International 0 DCME			International 1 DCME			International 2 DCME		
		T	Ie	R	T	Ie	R	T	Ie	R	T	Ie	R
B-Side	Trunk	141.6	5	81.7	253.2	5	70.6	282.22	12	59.8	310.22	19	49.4
	Wireless	231.5	10	72.7	346.5	10	58.3	374.5	17	48.54	402.5	24	38.98

Total E2E Delay (ms)

E-Model "R" factor

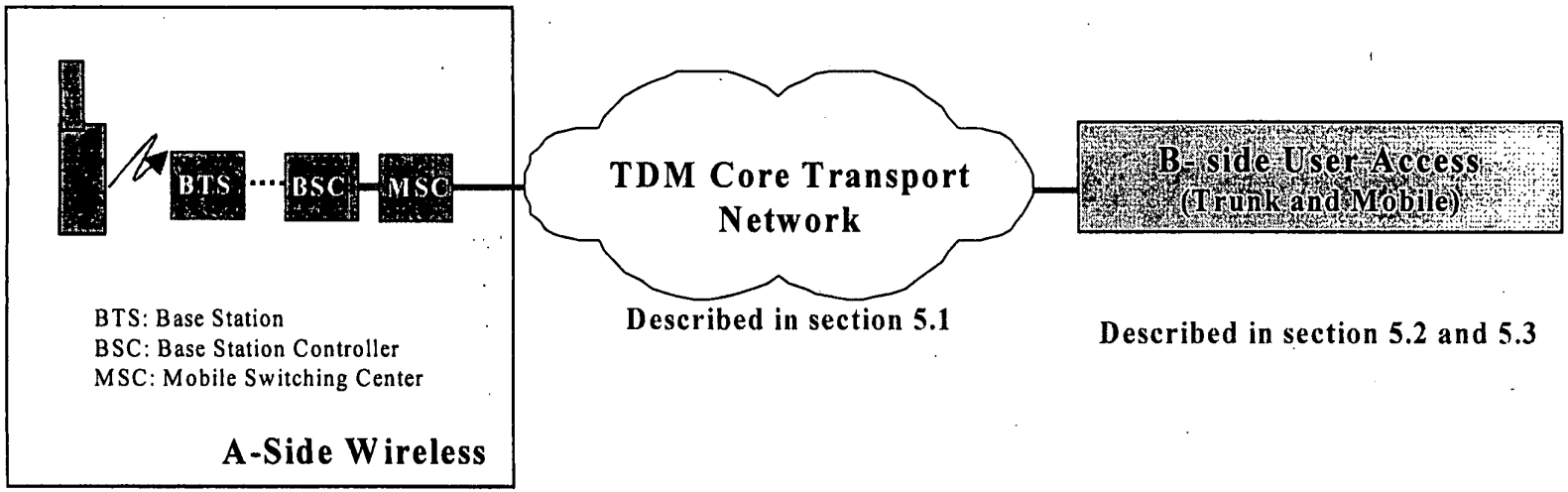
Total Impairment

Fig. 38



Trunk Access to	National			International 0 DCME			International 1 DCME			International 2 DCME		
	T	le	R	T	le	R	T	le	R	T	le	R
Trunk	46	0	87.8	161.22	0	85.8	190.22	7	76.8	218.22	14	66.6
Wireless	139.24	5	81.7	253.22	5	70.6	282.22	12	59.8	310.22	19	49.4

Fig. 39



Wireless Access to...	National			International 0 DCME			International 1 DCME			International 2 DCME		
	T	Ie	R	T	Ie	R	T	Ie	R	T	Ie	R
Trunk	141.6	5	81.7	253.2	5	70.6	282.22	12	59.8	310.22	19	49.4
Wireless	231.5	10	72.7	346.5	10	58.3	374.5	17	48.54	402.5	24	38.98

Fig. 40

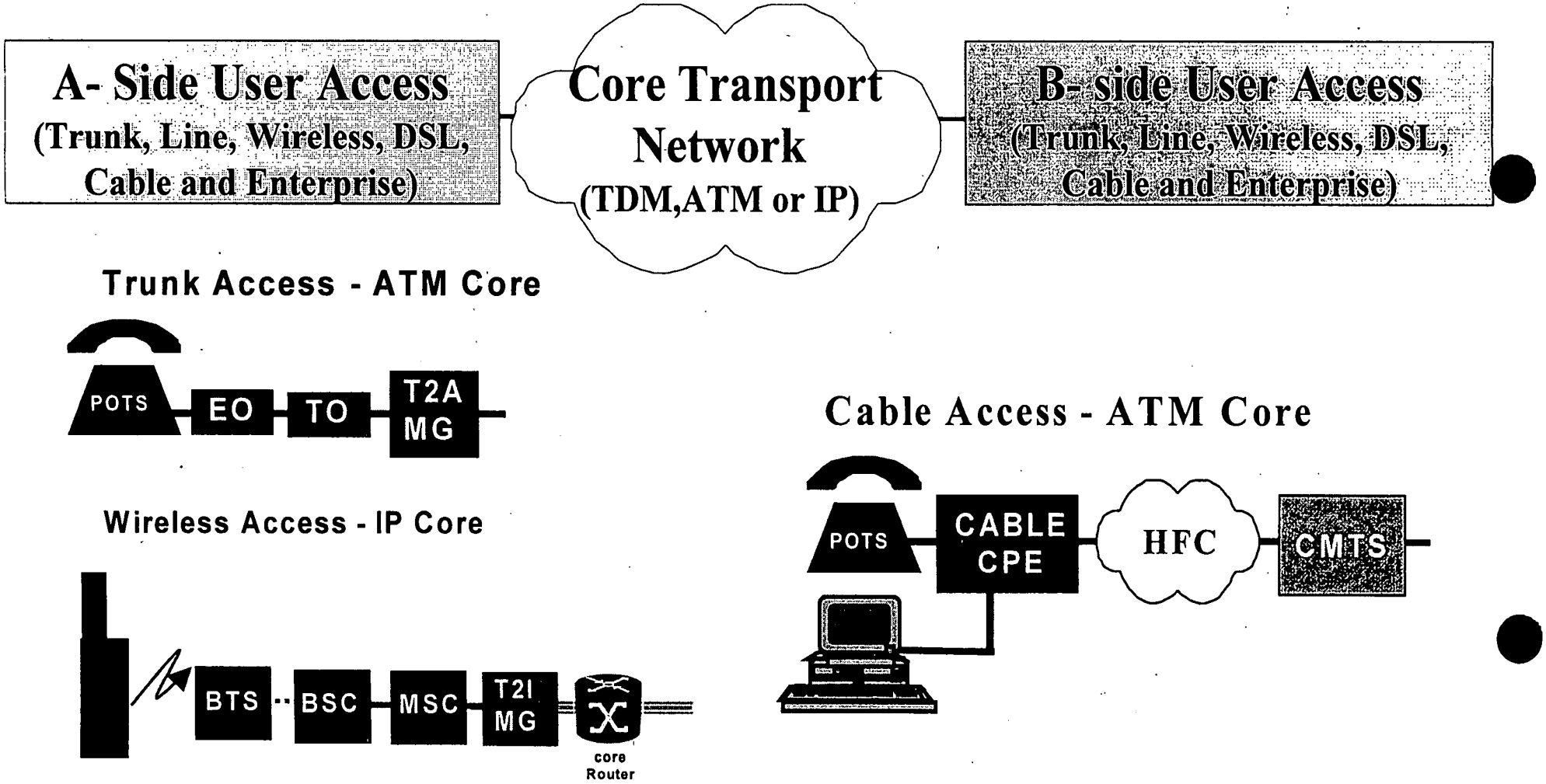
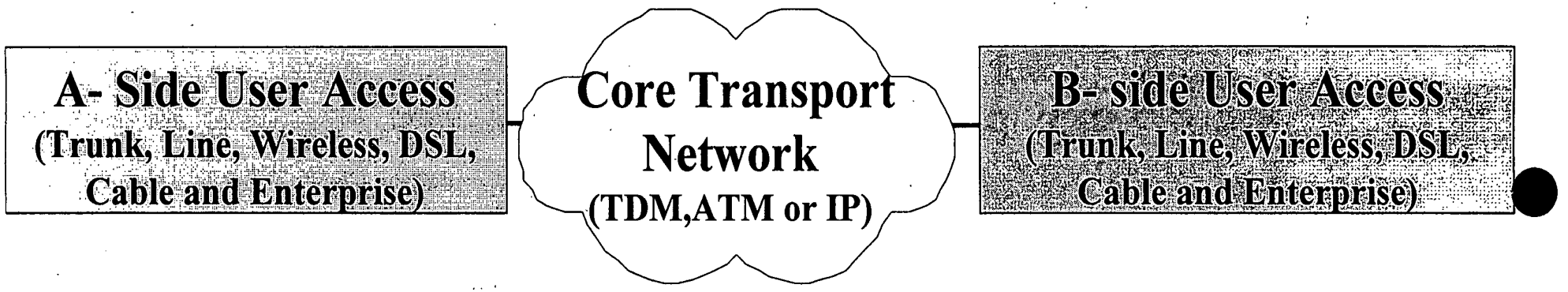
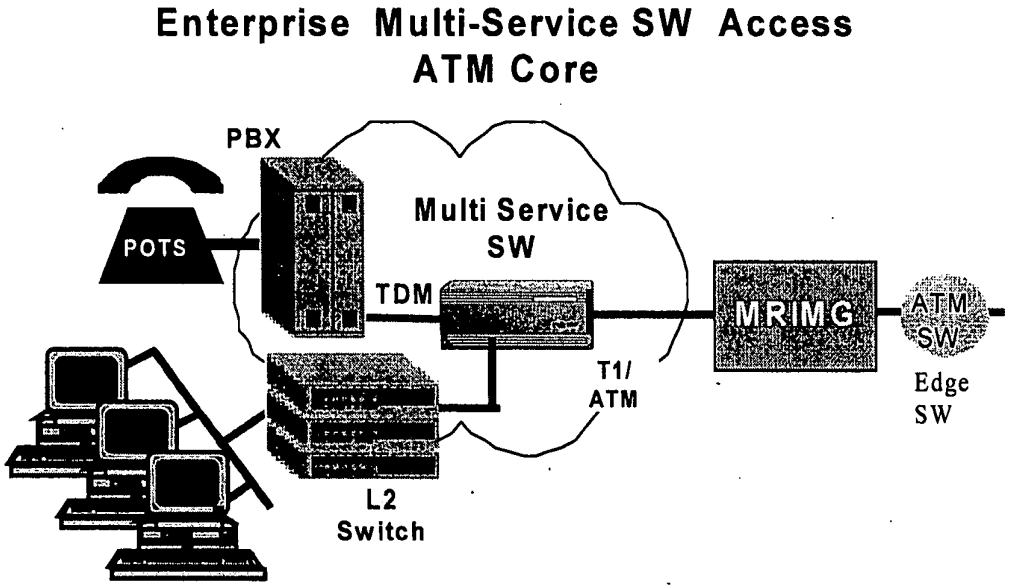

A- Side User Access
(Trunk, Line, Wireless, DSL, Cable and Enterprise)
Core Transport Network
(TDM,ATM or IP)
B- side User Access
(Trunk, Line, Wireless, DSL, Cable and Enterprise)
Trunk Access - ATM Core
POTS
EO
TO
T2A MG
Wireless Access - IP Core
BTS
BSC
MSC
T2I MG
core Router
Cable Access - ATM Core
POTS
CABLE CPE
HFC
CMTS

Fig. 41


A- Side User Access
(Trunk, Line, Wireless, DSL, Cable and Enterprise)
Core Transport Network
(TDM,ATM or IP)
B- side User Access
(Trunk, Line, Wireless, DSL, Cable and Enterprise)


Enterprise Multi-Service SW Access
ATM Core
PBX
POTS
Multi Service SW
TDM
MRIMG
ATM SW
Edge SW
T1/ ATM
L2 Switch

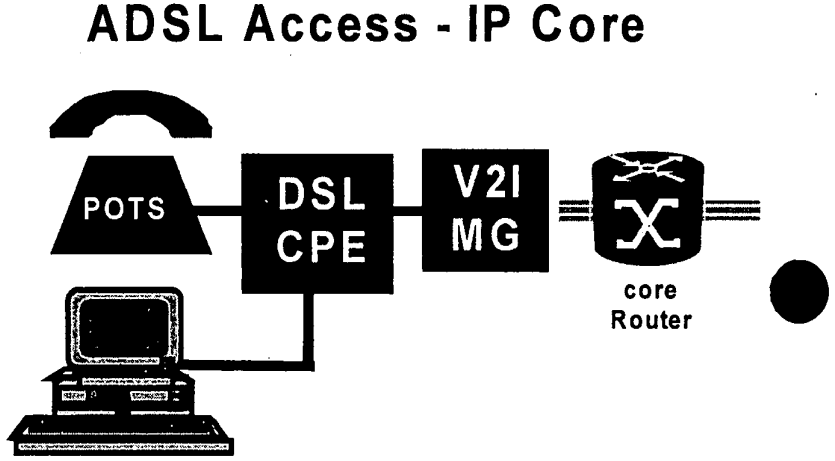

ADSL Access - IP Core
POTS
DSL CPE
V2I MG
core Router

Fig. 42

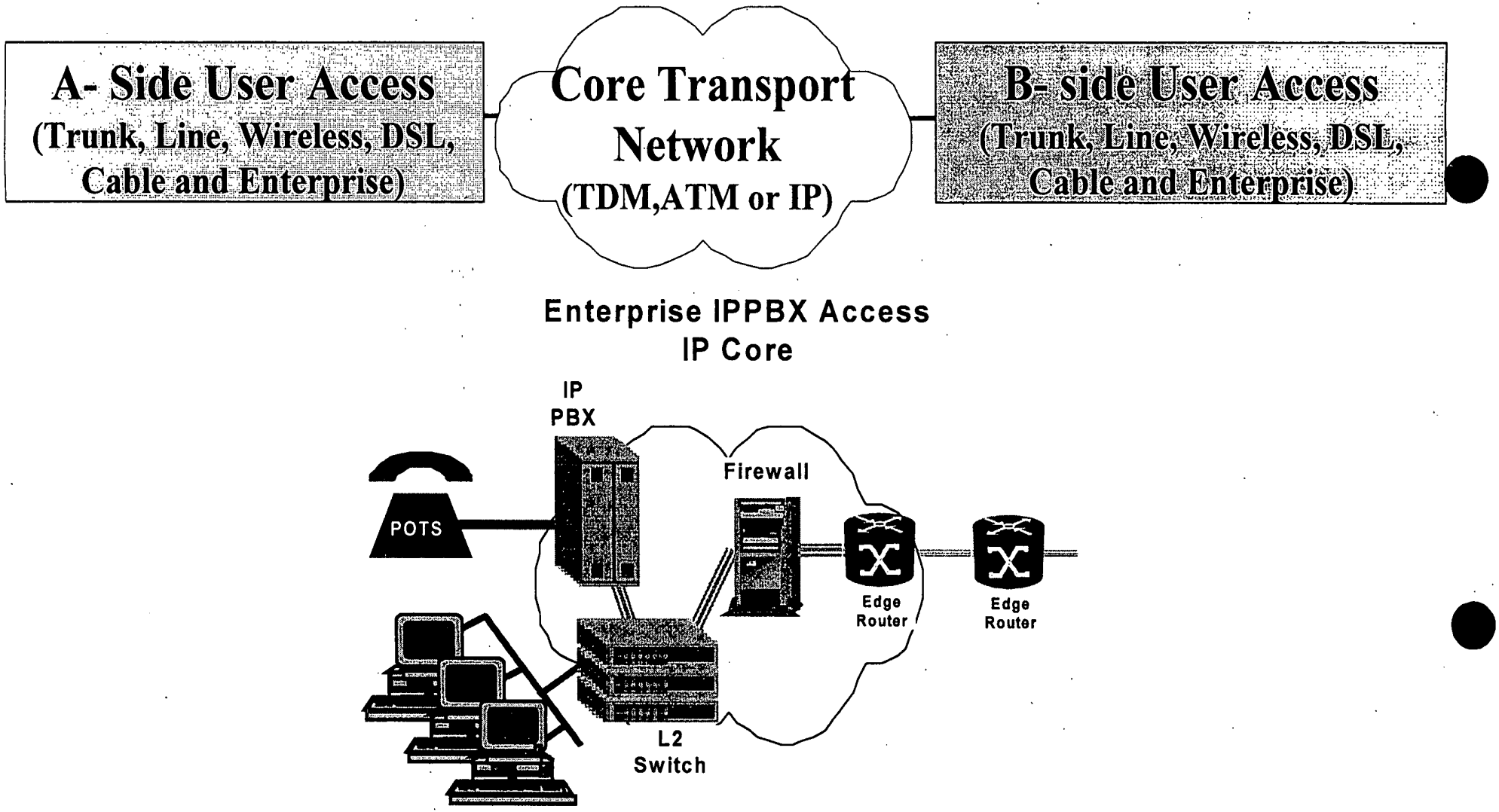

A- Side User Access
(Trunk, Line, Wireless, DSL, Cable and Enterprise)
Core Transport Network
(TDM,ATM or IP)
B- side User Access
(Trunk, Line, Wireless, DSL, Cable and Enterprise)
Enterprise IPPBX Access
IP Core
IP PBX
POTS
Firewall
Edge Router
Edge Router
L2 Switch

Fig. 43

Which impairments are being considered in the models?

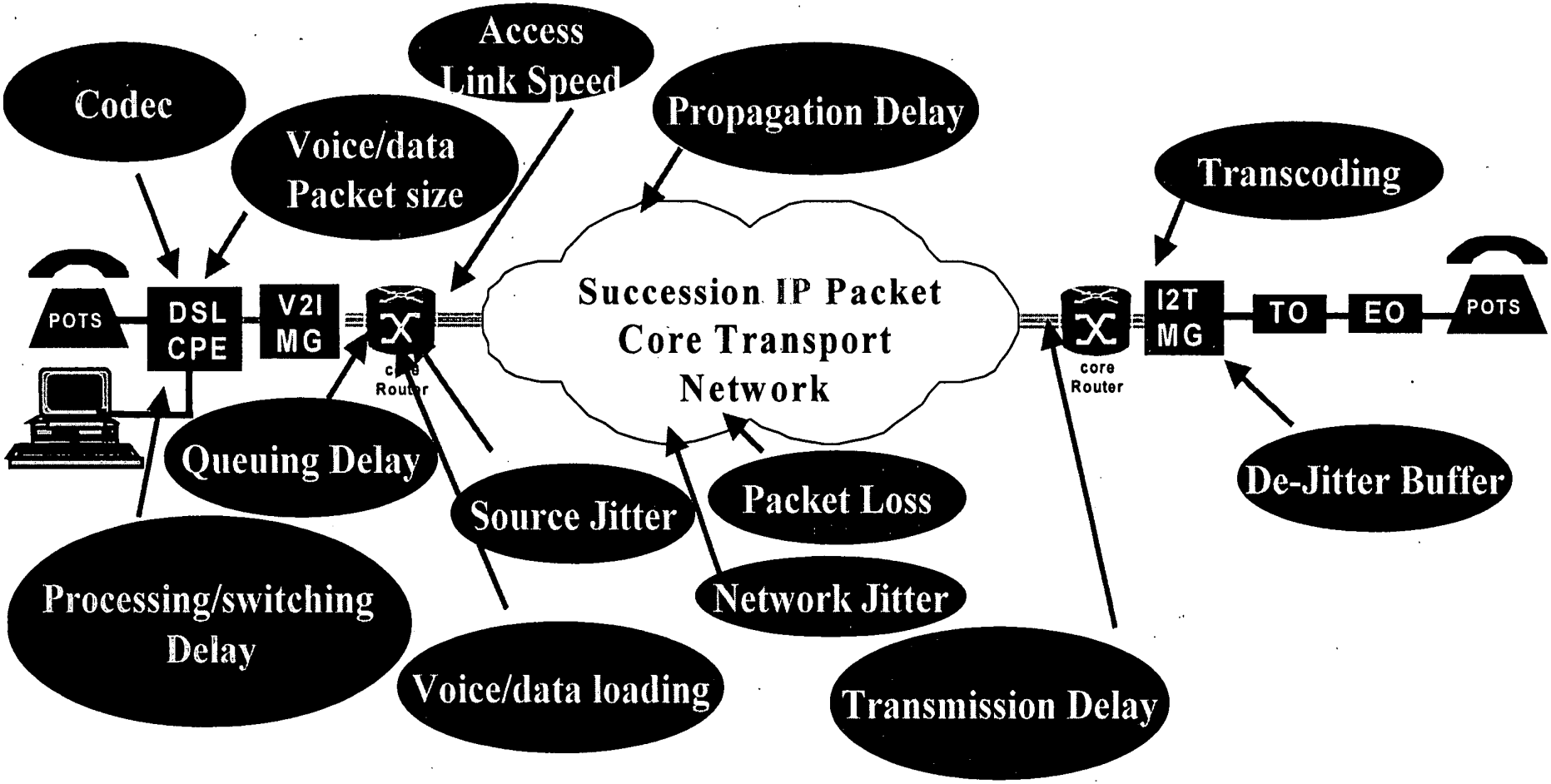
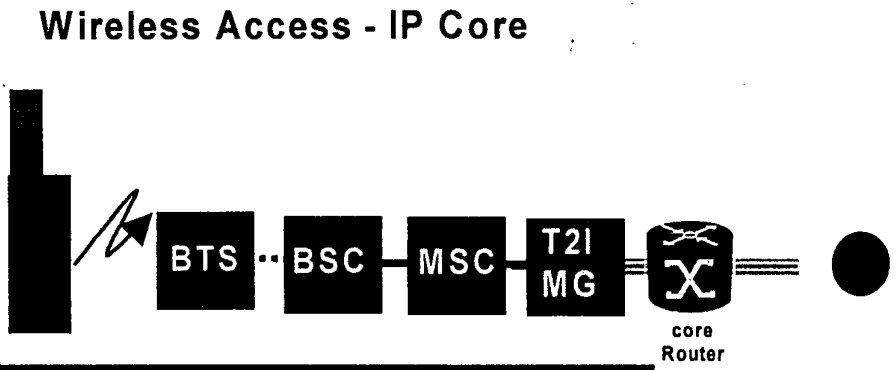


Fig. 44

Trunk Access - ATM Core

Trunk Access to ATM Core (before 4 parameters budget assignment) Delay, loss and Impairment Summary	
Set delay (Side A) (ms)	0
End Office Delay (Side A) (ms)	1.5
Tandem Office Delay (Side A) (ms)	0.75
T2AMG delay (Side A) (ms)	0.5
Trunk Access delay (ms)	**2.75**
Impairment Factor (Ie)	**0**

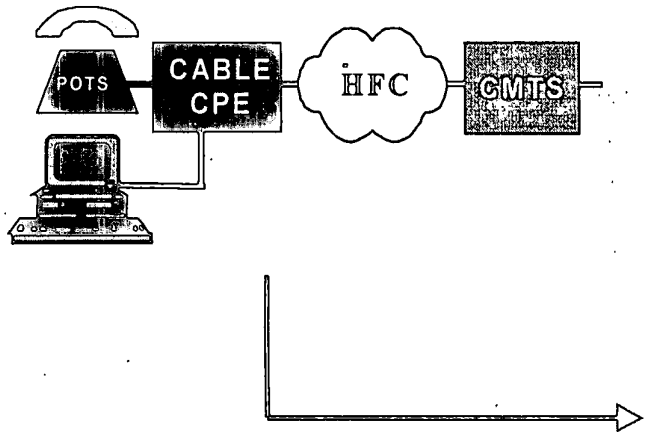
Fig. 45



Succession Wireless to ATM Core - Delay, loss ad Impairment Summary (before 4 parameters budget assignment)		
	Uplink	Downlink
Mobile Switching Center (MSC) (ms)	1	2
Base Station Controller (BSC) (ms)	2.5	40
Base Station (BTS) (ms)	15.8	40.8
Mobile Set (MS) (ms)	72.1	14.3
T2AMG delay (Side A) (ms)	0.5	0.5
Wireless Access delay (ms)	**91.40**	**97.10**
Impairment Factor (Ie)	**5**	**5**

Fig. 46

Cable Access - ATM Core



Cable CPE	Cable CPE Upstream	Cable CPE Downstream	Note
Link Speed	510 Kbps	3000 Kbps	note [1]
Voice packet size (byte)	160	160	note [2]
Voice packet overhead (RTP/UDP/IP)	48	48	
Data packet size (byte)	512	512	
Data packet overhead	48	48	
Voice packet link utilization (%)	10.0%	10.0%	
Data packet link utilization (%)	90.0%	90.0%	
Fixed Delay			
- Serialization delay for voice packet (ms)	3.26	0.55	note [3]
- DSP & CPU processing delay (ms)	12.00	14.00	note [4]
- Packetization Delay (ms)	0.00	N/A	note [5]
Variable Delay			
- Average Voice data contention (ms)	4.57	0.78	note [6]
- Maximum Voice data contention (ms)	9.15	1.55	note [6]
- De-Jitter buffer delay (ms)	N/A	0.00	note [5]
Other Impairments			
- Packet Loss (%)	0.00	0.00	note [5]
Minimum Delay (Fixed Delays) (ms)	15.26	14.55	
Average Delay (Fixed+Average Variable Delays) (ms)	19.84	15.33	
Maximum Delay (Fixed+ Max Variable Delays) (ms)	24.41	16.11	

Fig. 47

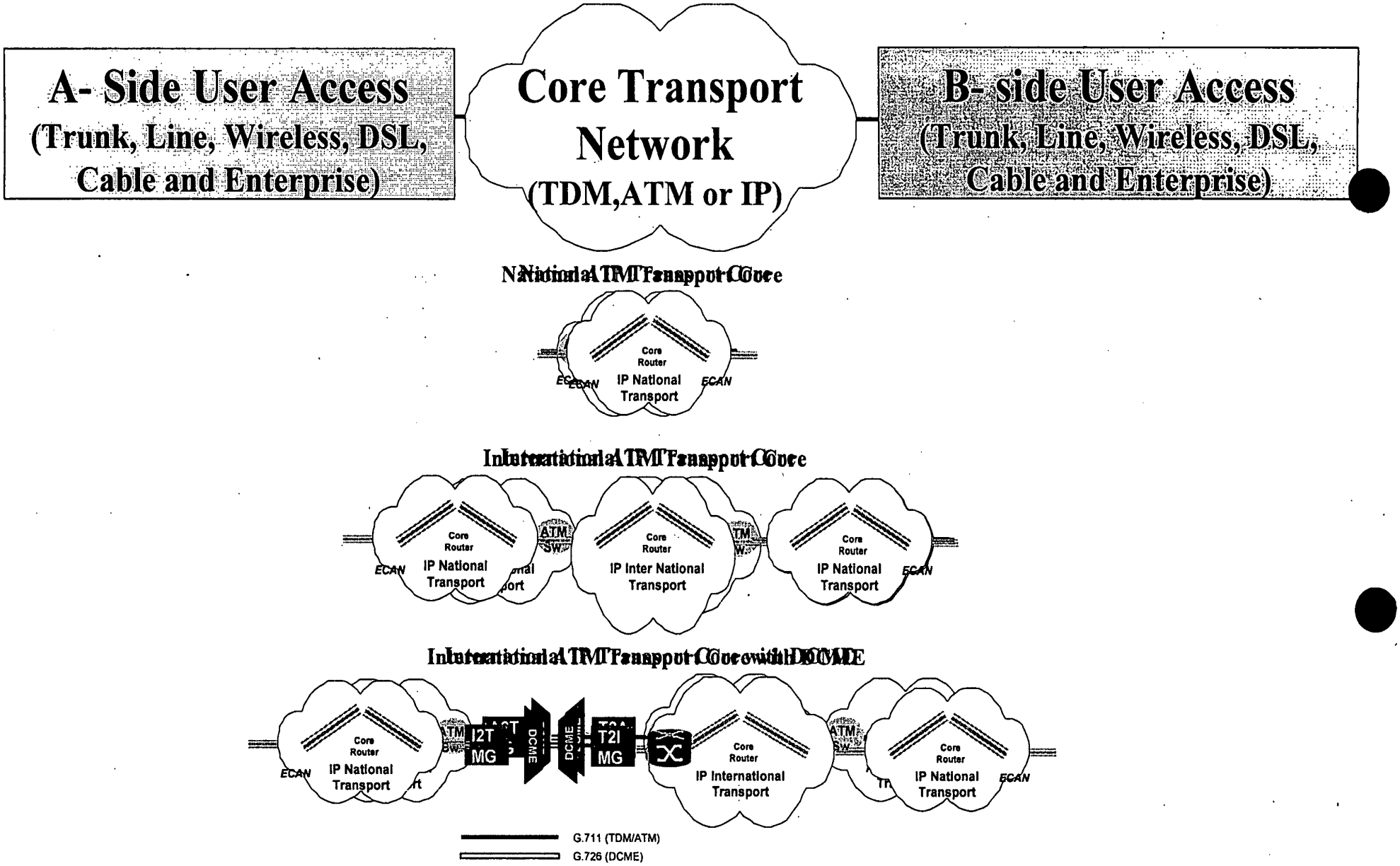
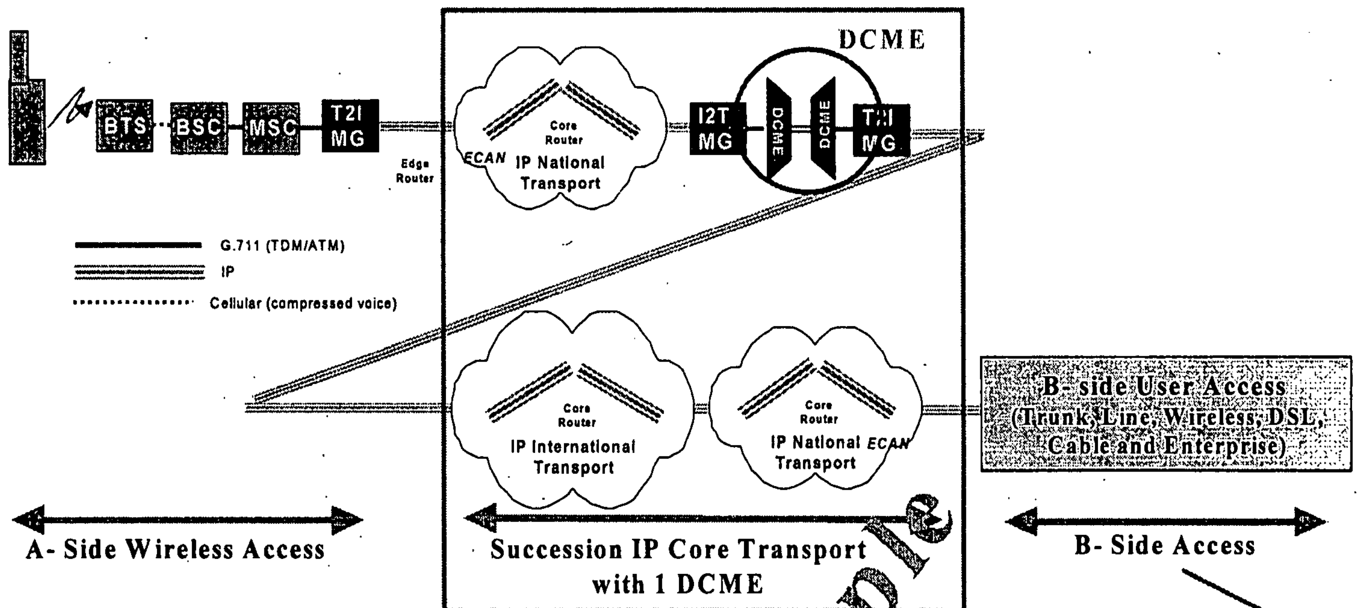

A- Side User Access
(Trunk, Line, Wireless, DSL, Cable and Enterprise)
Core Transport Network
(TDM,ATM or IP)
B- side User Access
(Trunk, Line, Wireless, DSL, Cable and Enterprise)
National ATM Transport Core
Core Router
IP National Transport
ECAN
International ATM Transport Core
Core Router
IP National Transport
ATM SW
IP Inter National Transport
IP National Transport
ECAN
International ATM Transport Core with DCME
Core Router
IP National Transport
ATM SW
I2T MG
DCME
T2I MG
IP International Transport
IP National Transport
ECAN
G.711 (TDM/ATM)
G.726 (DCME)

Fig. 48

Total National Transport Distance (km)	8000 km (IP)	8000 km (ATM)	8000 km (TDM)	Note
Terrestrial Distance (km)	8000	8000	8000	
Terrestrial propagation Delay @ 5us / km (ms)	40	40	40	From G.114
Submarine Distance (km)	-	-	-	
Submarine propagation Delay @ 6us / km (ms)	-	-	-	From G.114
Number of hop	5	8	4	From I.356, TIA IS-810 G.114
Equipment processing time (ms)	1ms x 5	0.03ms x 8	0.75ms x 4	
Jitter (ms)	note [1]	1.5 note [3]	0	I.356 QoS class 1
Total Delay (ms)	45	41.74	43	Note [2]

Internation Core Transport delay	**27500 (IP)**	**27500 (ATM)**	**27500 (TDM)**	**Note**
Terrestrial Distance (km)	16000	16000	16000	
Terrestrial Delay @ 5us / km (ms)	80	80	80	
Number of hop	15	19	12	From I.356, TIA IS-810
Equipment processing time per hop	1	0.03	0.75	G.114
Equipment processing time (ms)	15	0.57	9	G.115
Submarine Distance (km)	11500	11500	11500	
Submarine Delay @ 6us / km (ms)	69	69	69	
Jitter (ms)	note [1]	3	0	I.356 QoS class 1
Total Delay (ms)	**164**	**149.57**	**158**	**Note [2]**

Fig. 49



B-Side Access	Succesion IP Core Transport											
	National			International 0 DCME			International 1 DCME			International 2 DCME		
	T	Ie	R	T	Ie	R	T	Ie	R	T	Ie	R
Trunk	145	5	82	264	5	69	293	12	59	321	19	48
Line	142	5	82	261	[illegible]	70	290	12	69	318	19	48
Wireless	237	10	72	356	10	57	385	17	48	413	24	38
VoDSL	164	5	81	283	5	67	312	12	56	340	19	46
Cable	158	5	81	277	5	67	306	12	57	334	19	47
Enterprise MiSS	156	5	81	275	5	68	304	12	57	332	19	47
Enterprise IPPBX	172	5	80	291	5	66	320	12	65	348	19	45

R: Intrinsic R-factor (before parameter budget assuagement)

Ie: Total end-to-end intrinsic impairment (before parameter budget assuagement)

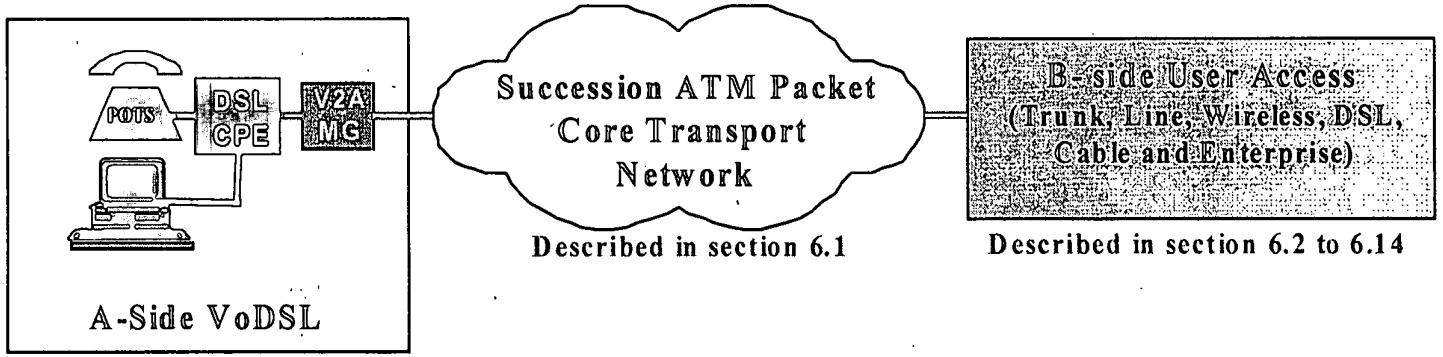
T: Total end-to-end intrinsic delay (before parameter budget assuagement)

Fig. 50

B-Side Access	ATM Core Transport											
	National			International 0 DCME			International 1 DCME			International 2 DCME		
	I	Ie	R	I	Ie	R	I	Ie	R	I	Ie	R
POTS Trunk	47	0	88	161	0	86	190	7	77	218	14	67
POTS Line	45	0	88	159	0	86	188	7	77	216	14	67
Wireless	139	5	82	253	5	71	282	12	60	310	19	49
VoDSL	66	0	87	180	0	85	209	7	75	237	14	64
Cable	61	0	88	175	0	85	204	7	75	232	14	65
Enterprise MSS	48	0	88	162	0	86	191	7	77	219	14	67
Enterprise PPBX	64	0	88	178	0	85	207	7	75	235	14	64

Note: The four parameters: packetization delay, delay jitter, codec and packet loss have been set to zero. Those four parameters will be determined based upon the available margin. The margin is determined based on the benchmark comparison of an end-to-end Succession network with the closest benchmark representation of existing networks (PSTN only, mobile to PSTN, or mobile to mobile).

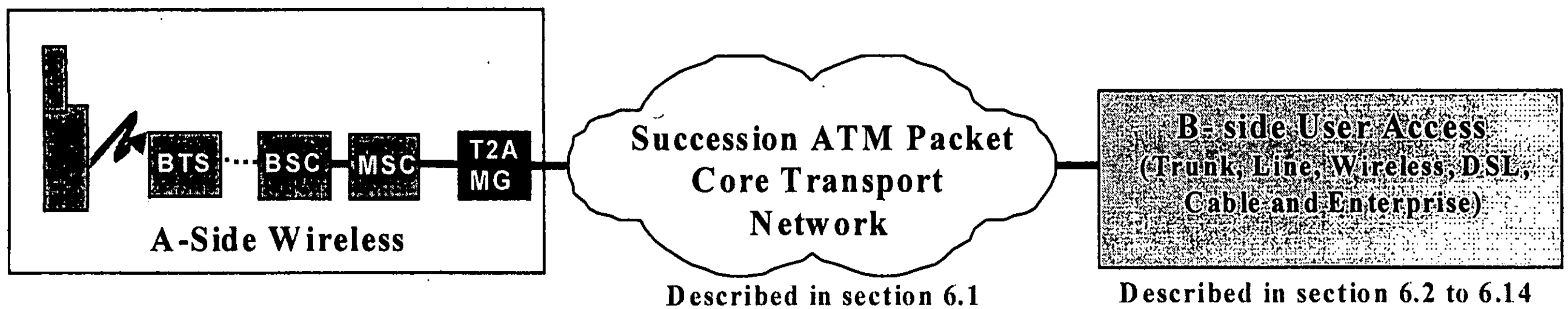
Fig. 51



B-Side Access	ATM Core Transport											
	National			International 0 DCME			International 1 DCME			International 2 DCME		
	I	Ie	R	I	Ie	R	I	Ie	R	I	Ie	R
POTS Trunk	66	0	87	180	0	85	209	7	75	237	14	64
POTS Line	64	0	88	178	0	85	207	7	75	235	14	64
Wireless	158	5	81	272	5	68	301	12	57	329	19	47
VoDSL	86	0	87	200	0	83	229	7	72	257	14	62
Cable	80	0	87	194	0	83	223	7	73	251	14	62
Enterprise MSS	67	0	87	181	0	85	210	7	75	238	14	64
Enterprise IPPBX	84	0	87	198	0	83	227	7	73	255	14	62

Note: The four parameters: packetization delay, delay jitter, codec and packet loss have been set to zero. Those four parameters will be determined based upon the available margin. The margin is determined based on the benchmark comparison of an end-to-end Succession network with the closest benchmark representation of existing networks (PSTN only, mobile to PSTN, or mobile to mobile).

Fig. 52



B-Side Access	IP Core Transport											
	National			International 0 DCME			International 1 DCME			International 2 DCME		
	T	Ie	R	T	Ie	R	T	Ie	R	T	Ie	R
POTS Trunk	145	5	86	264	5	74	293	12	63	321	19	53
POTS Line	142	5	86	261	5	74	290	12	64	318	19	53
Wireless	237	10	72	356	10	57	385	17	48	413	24	38
VoDSL	164	5	85	283	5	71	312	12	61	340	19	51
Cable	158	5	85	277	5	72	306	12	62	334	19	52
Enterprise MSS	156	5	85	275	5	72	304	12	62	332	19	52
Enterprise IPPBX	172	5	84	291	5	70	320	12	60	348	19	50

Note: The four parameters: packetization delay, delay jitter, codec and packet loss have been set to zero. Those four parameters will be determined based upon the available margin. The margin is determined based on the benchmark comparison of an end-to-end Succession network with the closest benchmark representation of existing networks (PSTN only, mobile to PSTN, or mobile to mobile).

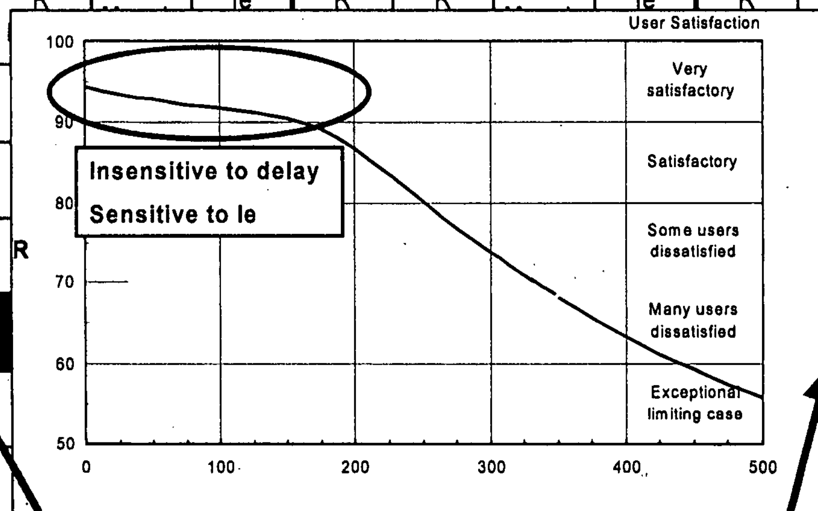
Fig. 53

R Succession

R "Clarity" Benchmark

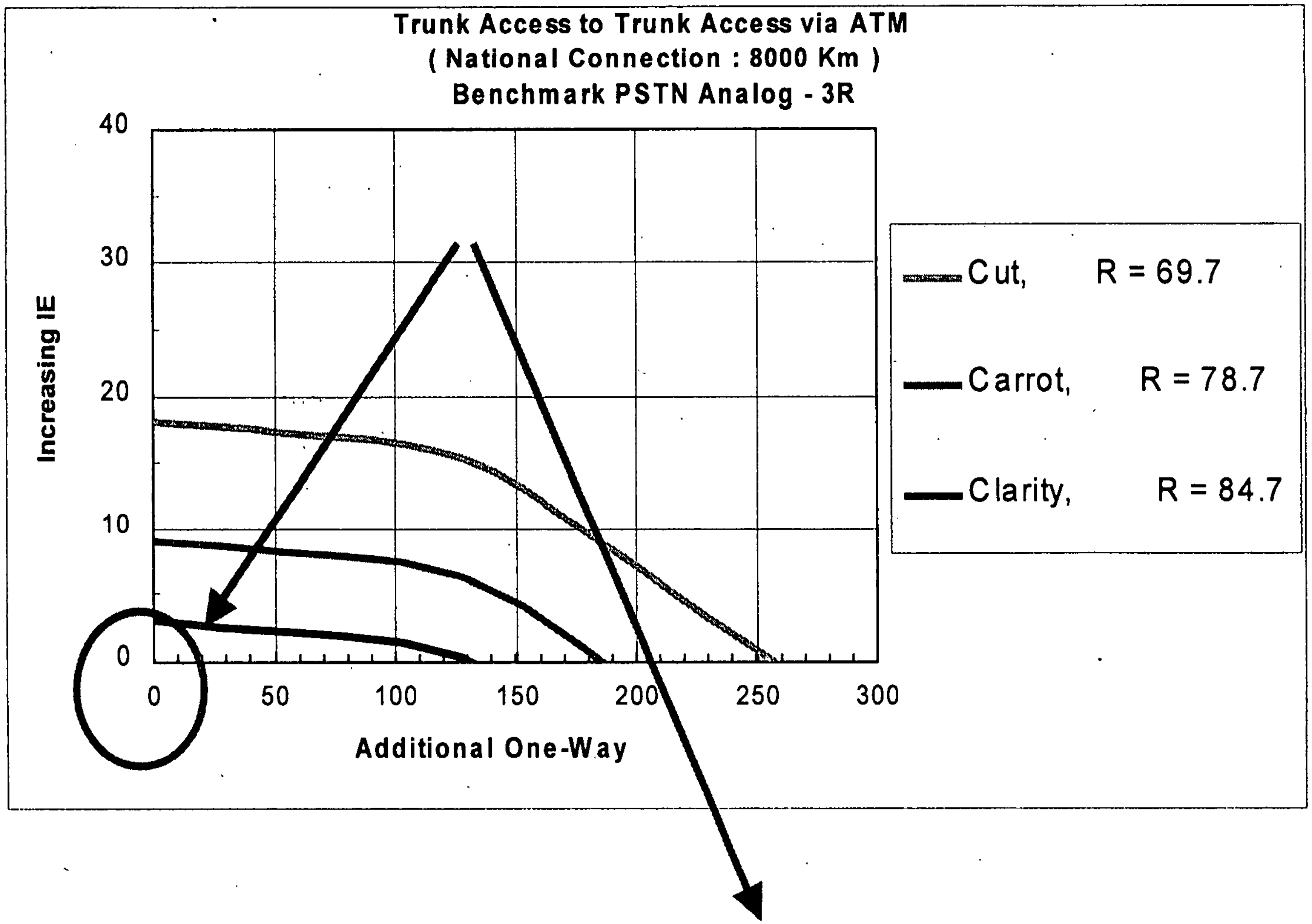
B- Side Access	ATM Core Transport Network															
	Succ vs PSTN National				Succ 0 DCME vs PSTN Intl 0 DCME				Succ 0 DCME vs PSTN Intl 1 DCME				Succ 0 DCME vs PSTN Intl 2 DCME			
	R Succ	R PSTN	Delay Margin (ms)	Ie Margin	R Succ	R	Delay	Ie	R	R	Delay	Ie	R	R PSTN	Delay Margin (ms)	Ie Margin
POTS Trunk	87.8	87.8	-1.2	0.0	85.8									66.6	171.8	19.2
POTS Line	87.9	87.[illegible]	1.0	0.1	85.9									66.6	174.0	19.3
Wireless	81.8	81.7	-1.2	0.1	70.7									[illegible].4	196.8	21.3
VoDSL	87.5	87.[illegible]	-20.4	-0.2	84.6									[illegible].6	152.6	18.0
Cable	87.6	87.8	-14.9	-0.2	8[illegible].0									66.6	158.1	18.4
Enterprise MSS	87.8	87.8	-1.6	0.0	85.8									66.6	171.5	19.2
Enterprise IPPBX	87.5	87.8	-18.4	-0.3	84.8	85.8							8	66.6	154.7	18.2

Note: In red indicates the worst case access scenario with the smallest available budget



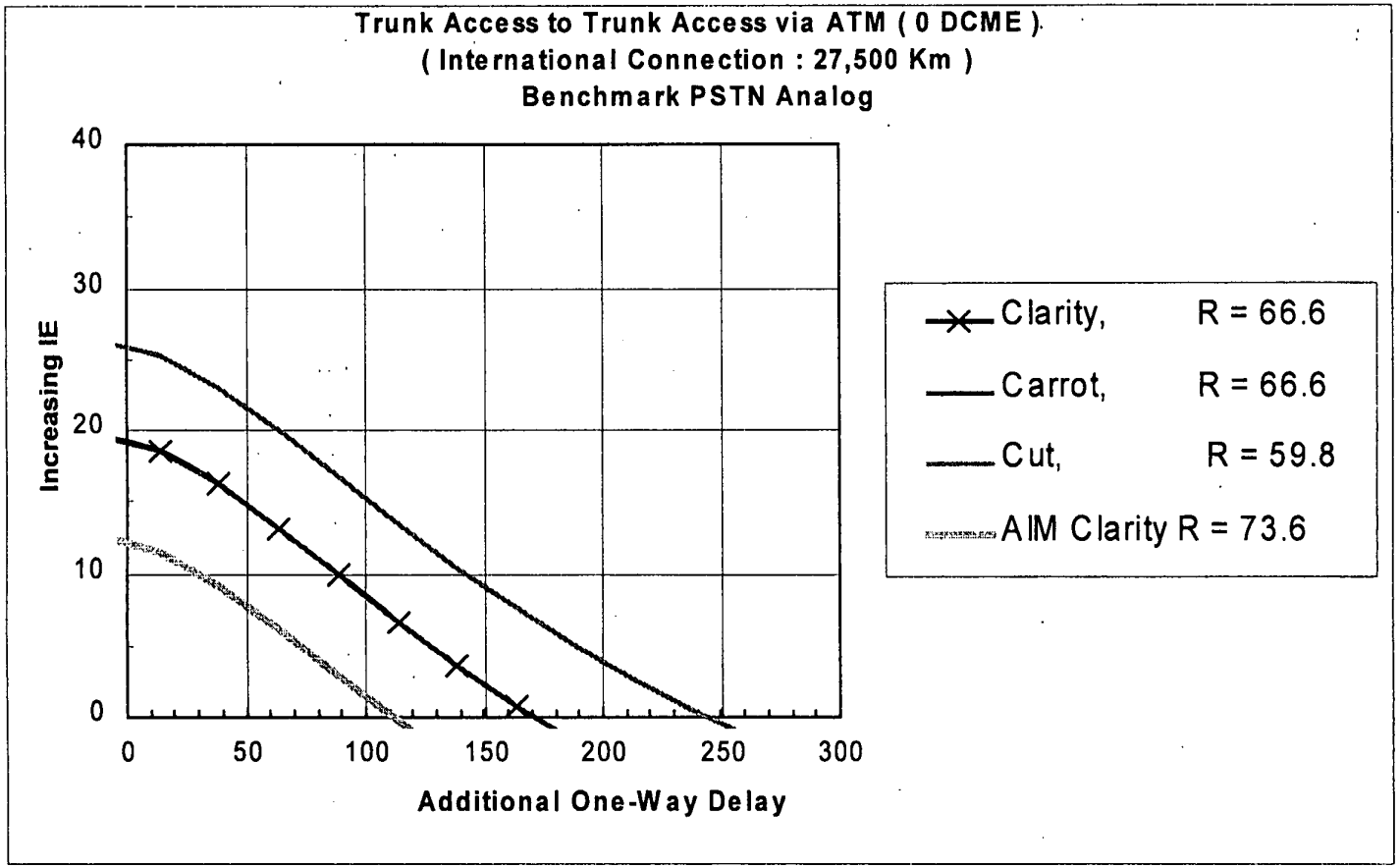
Available Margins

Fig. 54



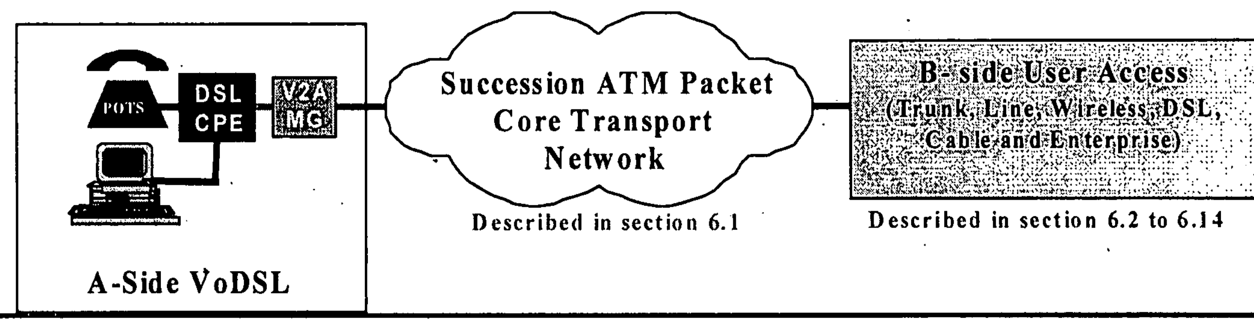
Ie Budget =	3	9	18
Delay Budget =	130	186	257

Fig. 55



Ie Budget =	12.07	19.07	19.07	25.87
Delay Budge	110.9	171.5	171.5	244.4

Fig. 56



	ATM Core Transport Network															
	Succ vs PSTN National				Succ 0 DCME vs PSTN Intl 0 DCME				Succ 0 DCME vs PSTN Intl 1 DCME				Succ 0 DCME vs PSTN Intl 2 DCME			
B- Side Access	R Succ	R PSTN	Delay Margin (ms)	Ie Margin	R Succ	R PSTN	Delay Margin (ms)	Ie Margin	R Succ	R PSTN	Delay Margin (ms)	Ie Margin	R Succ	R PSTN	Delay Margin (ms)	Ie Margin
POTS Trunk	87.5	87.8	-20										4.6	66.6	152.6	18.0
POTS Line	87.5	87.8	-18										4.8	66.6	154.8	18.2
Wireless	81.2	81.7	-20										8.1	49.4	177.6	18.7
VoDSL	87.2	87.7	-39										2.8	66.6	133.4	16.2
Cable	87.3	87.8	-34										3.4	66.6	138.9	16.8
Enterprise MSS	87.5	87.8	-20										4.6	66.6	152.3	18.0
Enterprise IPPBX	87.2	87.8	-37										3.0	66.6	135.5	16.4

Note: In red indicates the worst c

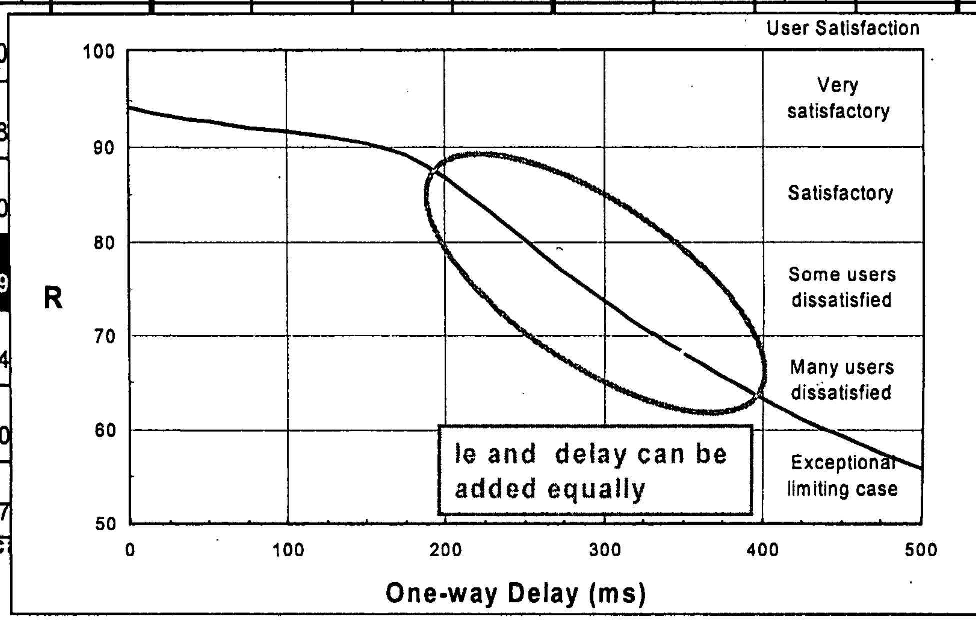
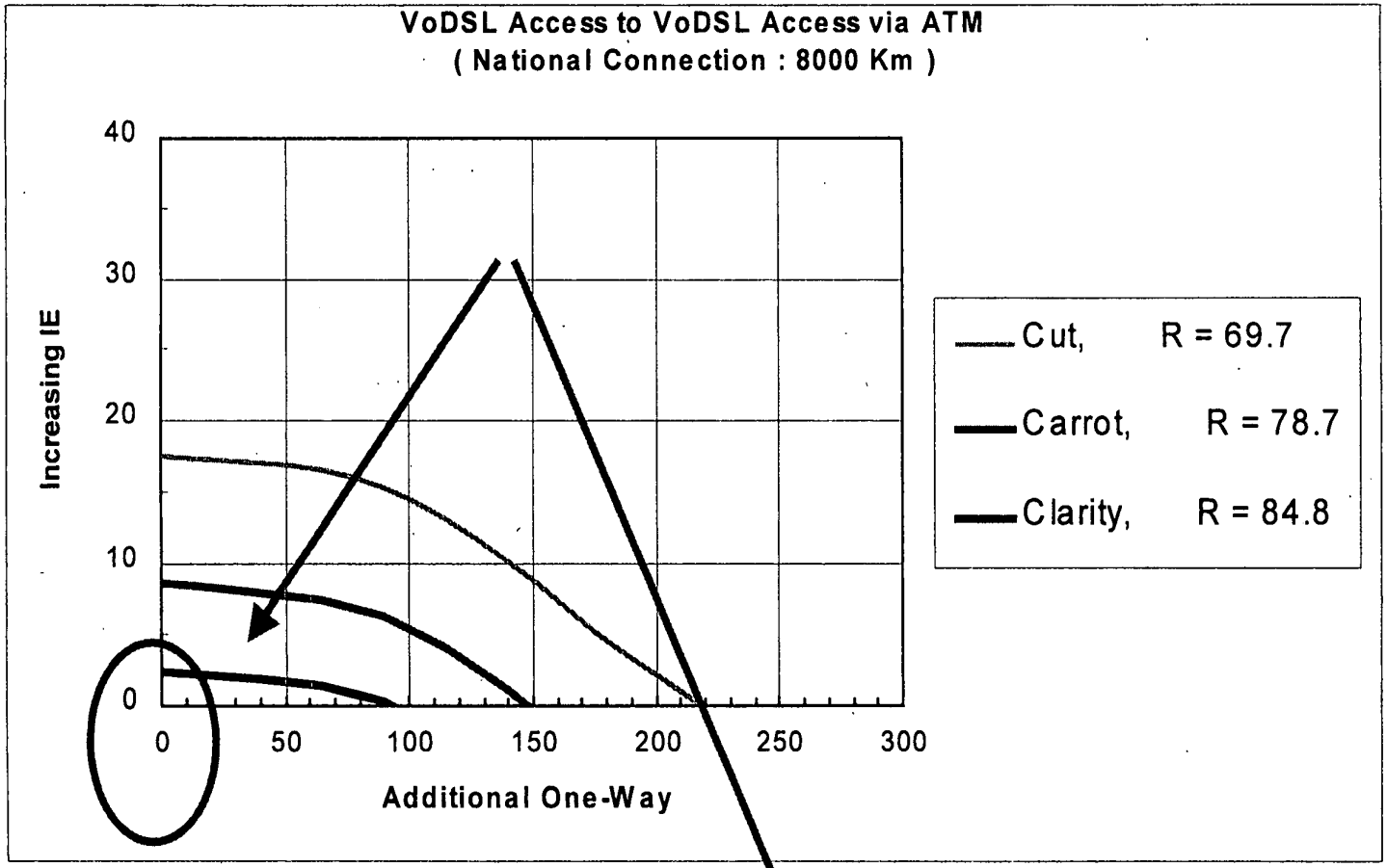
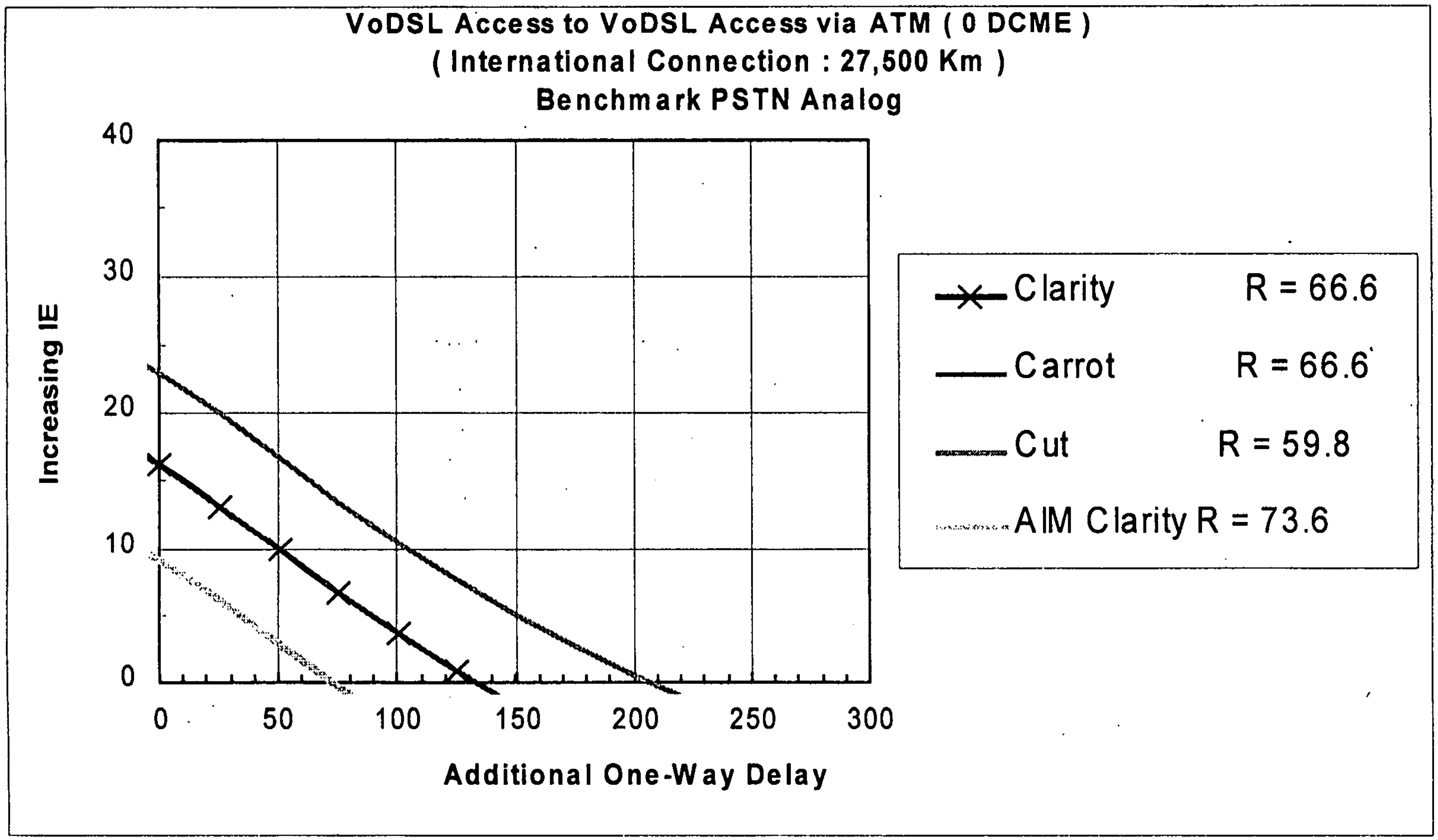


Fig. 57



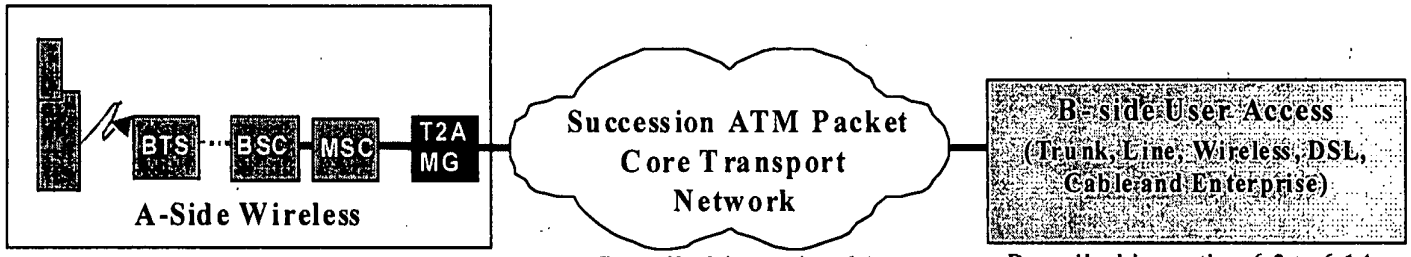
Ie Budget =	2	8	17
Delay Budget =	92	147	219

Fig. 58



Ie Budget =	9.207	16.21	16.21	23.01
Delay Budget =	72.54	133.1	133.1	206

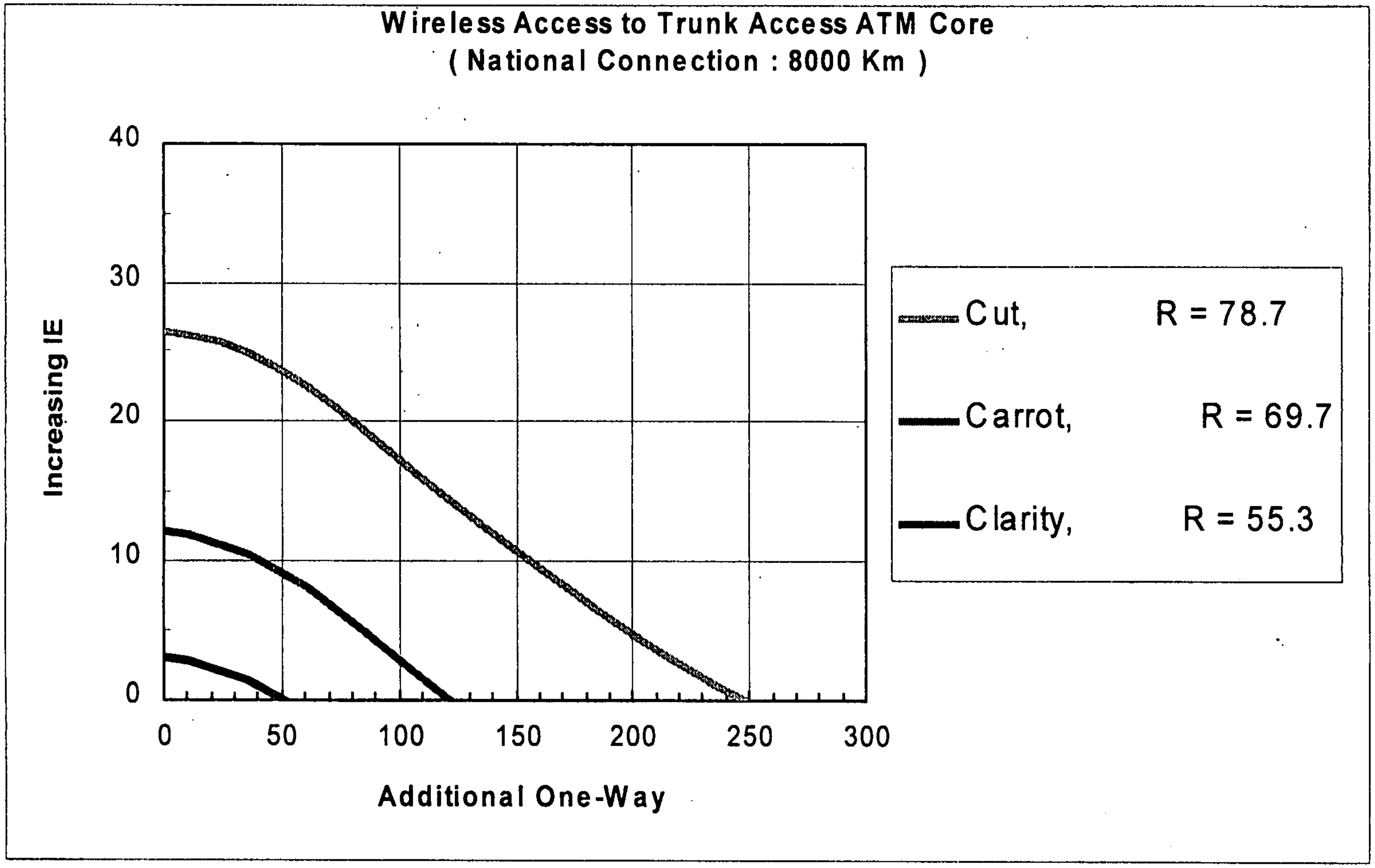
Fig. 59



		ATM Core Transport Network															
		Succ vs PSTN National				Succ 0 DCME vs PSTN Intl 0 DCME				Succ 0 DCME vs PSTN Intl 1 DCME				Succ 0 DCME vs PSTN Intl 2 DCME			
		R Succ	R PSTN	Delay Margin (ms)	Ie Margin	R Succ	R PSTN	Delay Margin (ms)	Ie Margin	R Succ	R PSTN	Delay Margin (ms)	Ie Margin	R Succ	R PSTN	Delay Margin (ms)	Ie Margin
B- Side Access	POTS Trunk	81.8	81.7	-1.2	0.1	70.7	70.6	-0.2	0.1	70.7	59.8	91.8	10.9	70.7	49.4	196.8	21.3
	POTS Line	81.8	81.7	1.0	0.1	71.0	70.6	2.0	0.4	71.0	59.8	94.0	11.2	71.0	49.4	199.0	21.6
	Wireless	72.7	72.7	-0.2	0.0	58.5	58.3	0.8	0.2	58.5	48.5	17.8	10.0	58.5	39.0	192.8	19.5
	VoDSL	81.2	81.7	-20.4	-0.5	68.1	70.6	-19.4	-2.5	68.1	59.8	72.6	8.3	68.1	49.4	177.6	18.7
	Cable	81.4	81.7	-14.9	-0.3	68.8	70.6	-13.9	-1.8	68.8	59.8	78.1	9.0	68.8	49.4	183.1	19.4
	Enterprise MSS	81.8	81.7	-1.6	0.1	70.6	70.6	-0.5	0.0	70.6	59.8	91.5	10.8	70.6	49.4	196.5	21.2
	Enterprise IPPBX	81.2	81.7	-18.4	-0.5	68.4	70.6	-17.3	-2.2	68.4	59.8	74.7	8.6	68.4	49.4	179.7	19.0

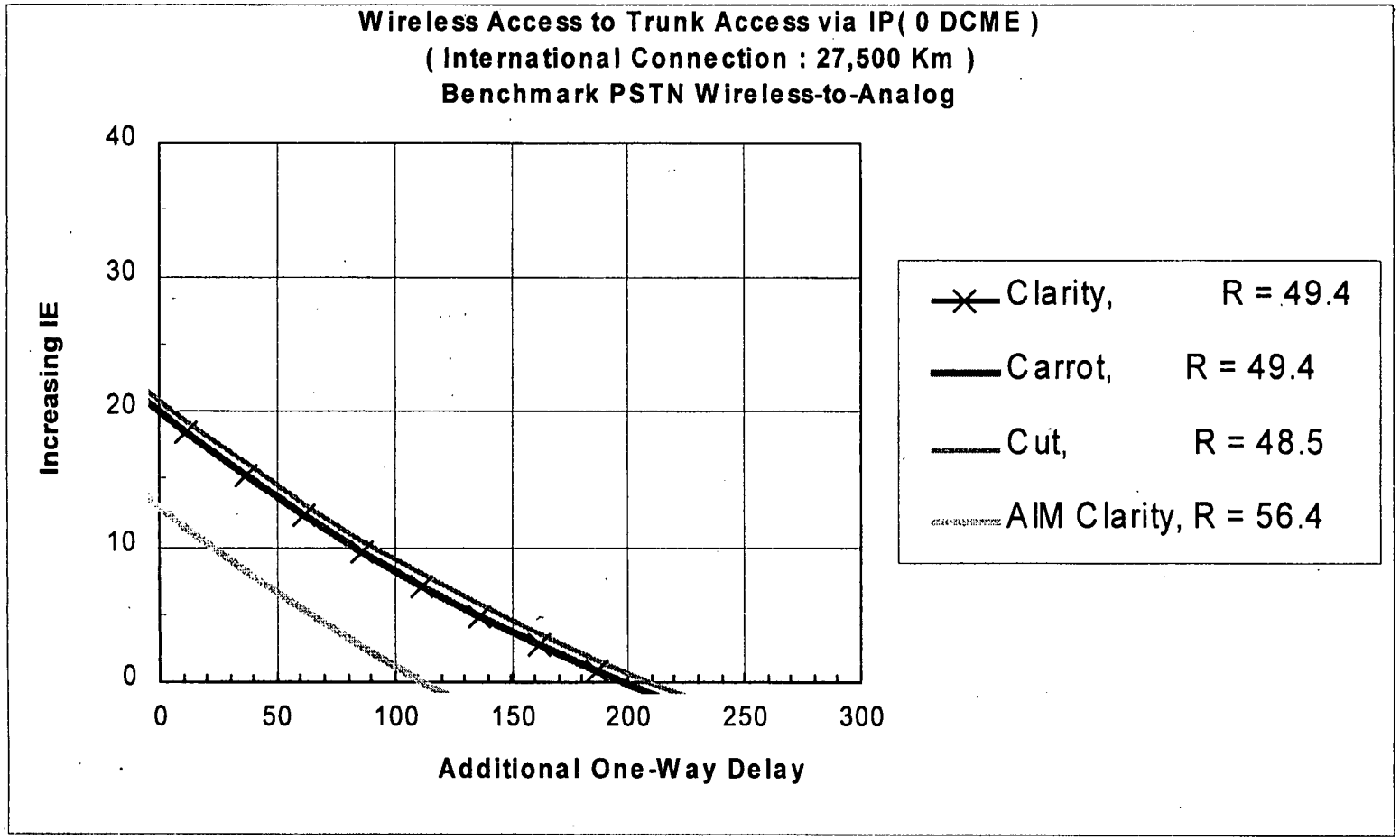
Note: In red indicates the worst case access scenario with the smallest available budget

Fig. 60



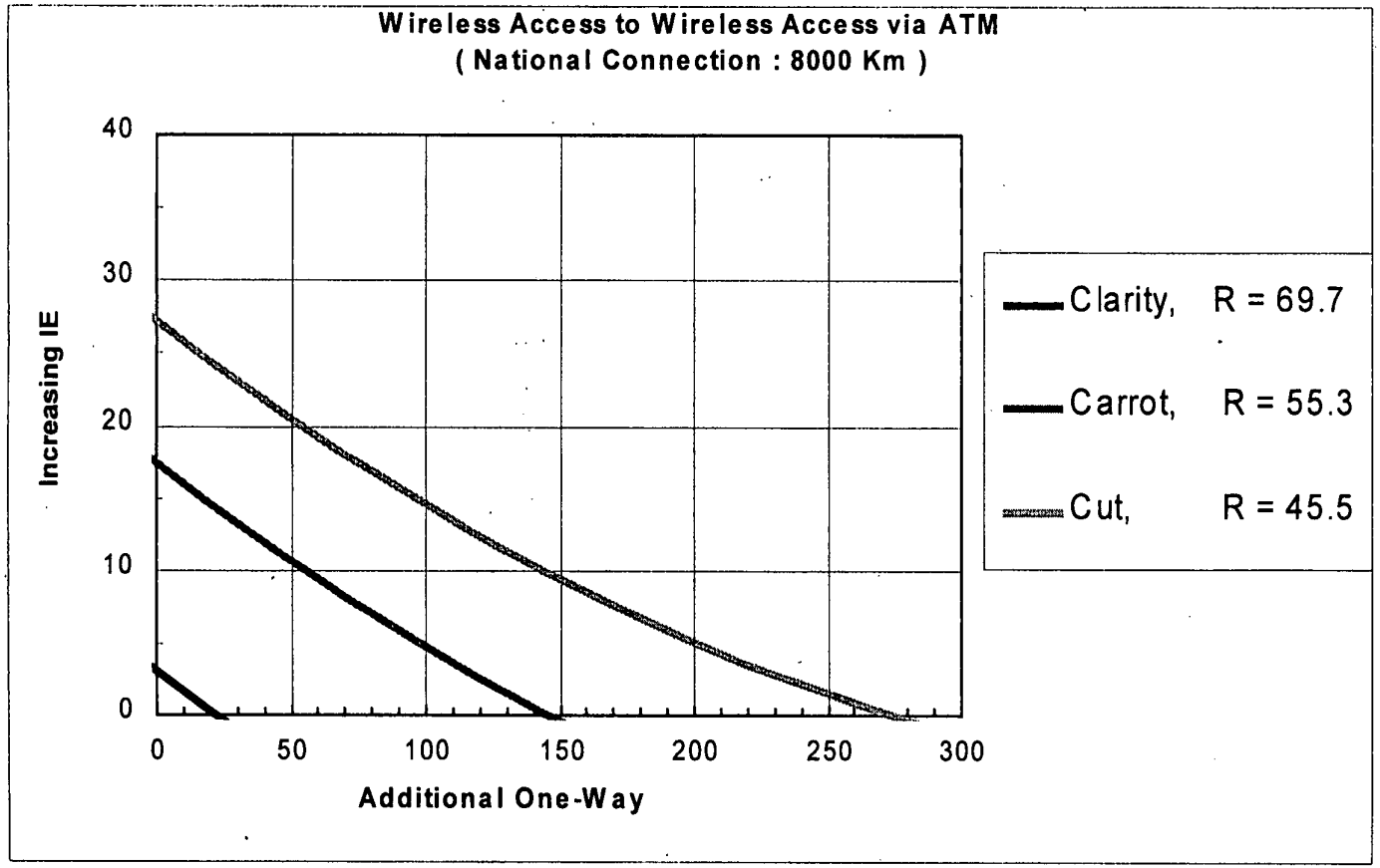
Ie Budget =	3	12	26
Delay Budget =	51	121	249

Fig. 61



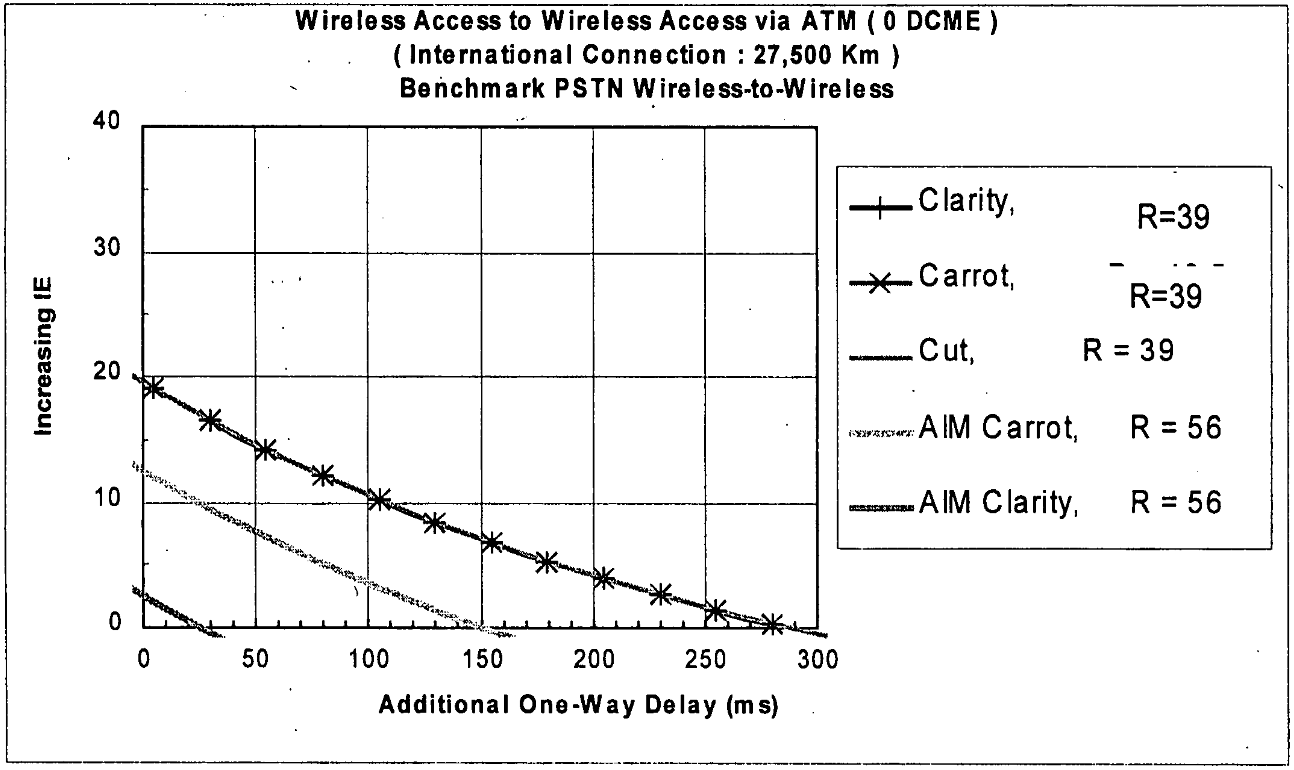
Ie Budget =	12.91	20	20	21
Delay Budget =	112.4	197	197	210

Fig. 62



Delay Budget =	3.004	17.34	27.14
le Budget =	21.97	145.8	273.1

Fig. 63



Ie Budget =	2	12	19	19	19
Delay Budget =	25	151	181	248	289

Fig. 64

Rank	Codec	E-model Impairment Factor (Ie)	Estimated implementation delay (ms)	Note
1	G.711 at 64 kb/s	0	0.125	PCM
2	G.726 at 32 kb/s with Synch Coding	7	0.250	ADPCM
3	GSM-EFR	5	40	GSM
4	IS-733	*	40	
5	G.728 at 16 kb/s	7	1.250	
6	G.729/G.729A at 8 kb/s	10/11	25	
7	IS-641	6	40	TDMA
8	G.723.1 at 6.3 kb/s (not recommended)	15	30	Soft Phone

Fig. 65

Codec		packetization delay (ms)	max packet loss (%)	Ie due to packet loss
type	Codec Ie			
G.711	0	10	0%	0
G.711	0	20	0%	0
G.726(1)	7	10	0%	0

1. This codec is only really suitable for international

Fig. 66

Codec		packetization delay (ms)	max packet loss (%)	Ie due to packet loss
type	Codec Ie			
G.711	0	10	0%	0
G.711	0	20	0%	0
G.711	0	40	0%	0
G.726	7	10	0%	0
G.726	7	20	0%	0
G.726	7	40	0%	0
G.711	0	10	1%	5
G.711	0	20	1%	5

Fig. 67

Codec		packetization delay (ms)	max packet loss (%)	Ie due to packet loss
type	Codec Ie			
G.711	0	10	0%	0
G.711	0	20	0%	0
G.711	0	40	0%	0
G.726	7	10	0%	0
G.726	7	20	0%	0
G.726	7	40	0%	0
G.729	11	10	0%	0
G.729	11	20	0%	0
G.729	11	40	0%	0
G.711	0	10	1%	5
G.711	0	20	1%	5
G.711	0	40	1%	5
G.726	7	10	1%	2
G.726	7	20	1%	4
G.726	7	40	1%	8
G.729	11	10	1%	2
G.729	11	20	1%	4

Fig. 68

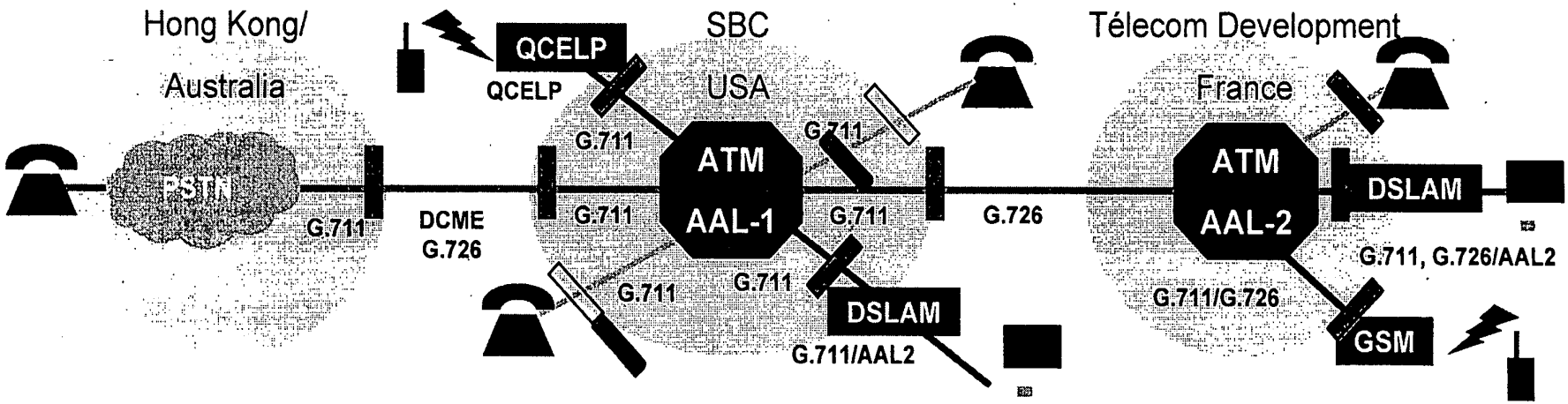

Hong Kong/
Australia
PSTN
G.711
DCME
G.726
QCELP
QCELP
SBC
USA
G.711
G.711
G.711
G.711
G.711
ATM
AAL-1
DSLAM
G.711/AAL2
G.726
Télecom Development
France
ATM
AAL-2
DSLAM
G.711, G.726/AAL2
G.711/G.726
GSM

Fig. 69

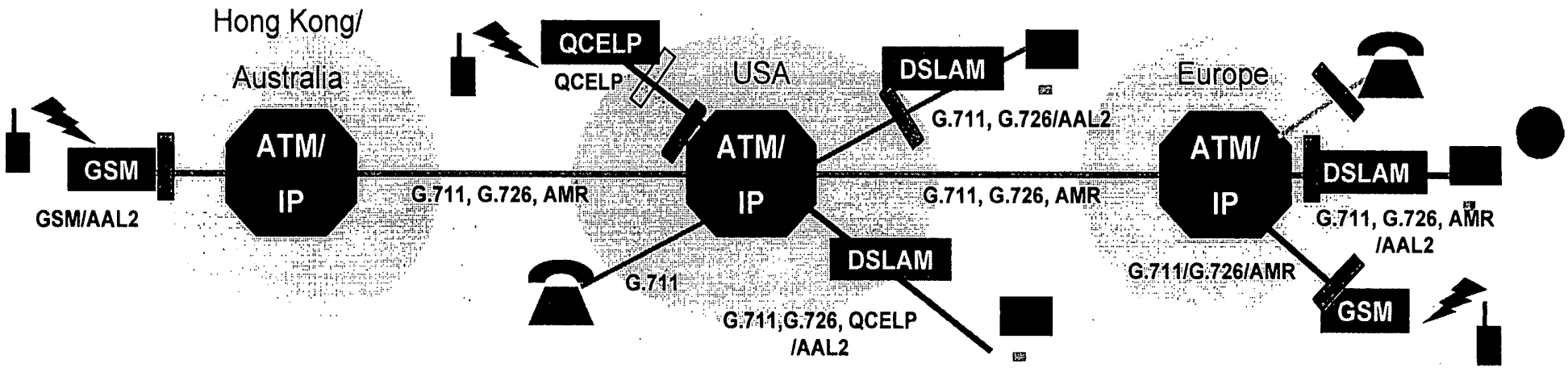
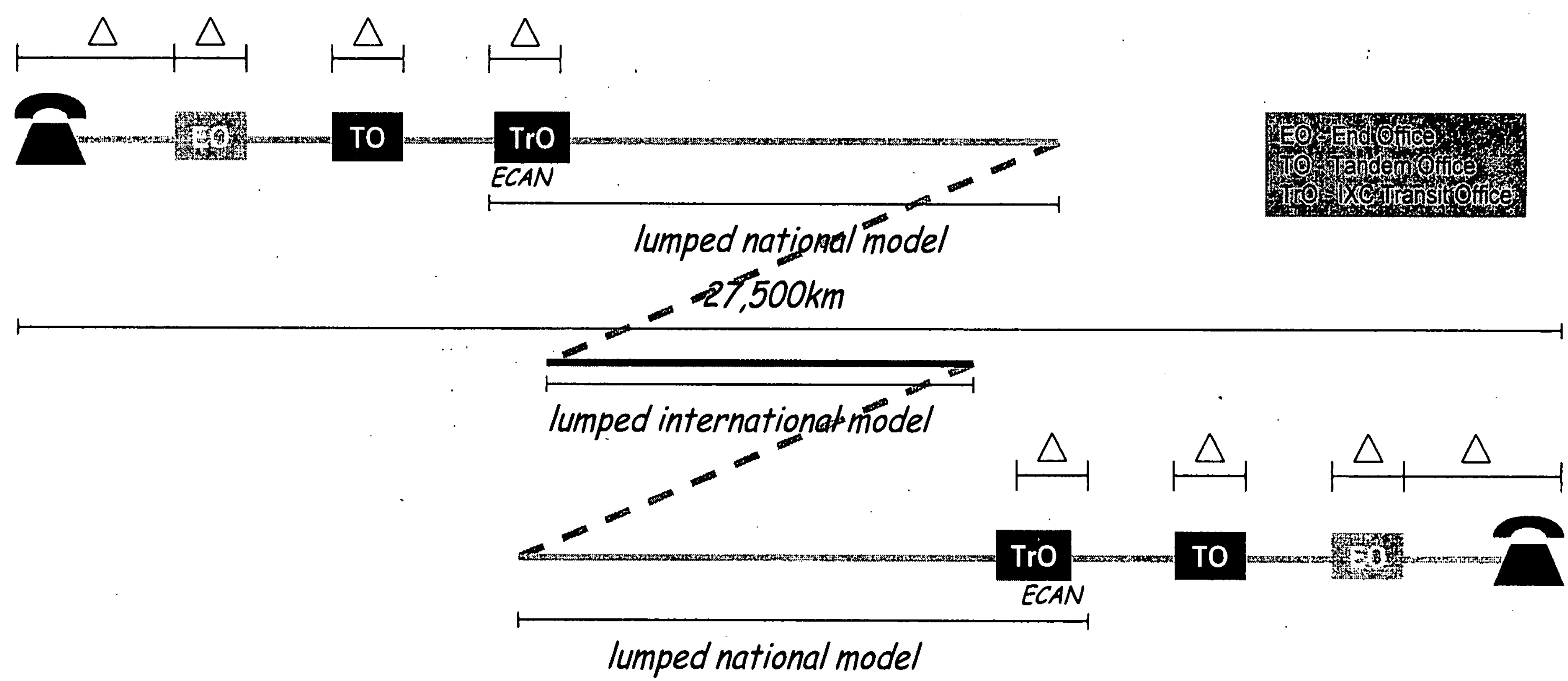

Hong Kong/
Australia
USA
Europe
QCELP
QCELP
GSM
GSM/AAL2
ATM/
IP
ATM/
IP
ATM/
IP
G.711, G.726, AMR
G.711, G.726, AMR
DSLAM
G.711, G.726/AAL2
DSLAM
G.711, G.726, AMR
/AAL2
G.711
DSLAM
G.711,G.726, QCELP
/AAL2
G.711/G.726/AMR
GSM

Fig. 70



EO - End Office
TO - Tandem Office
TrO - IXC Transit Office
TO
TrO
ECAN
lumped national model
27,500km
lumped international model
TrO
ECAN
TO
lumped national model

Fig. 71

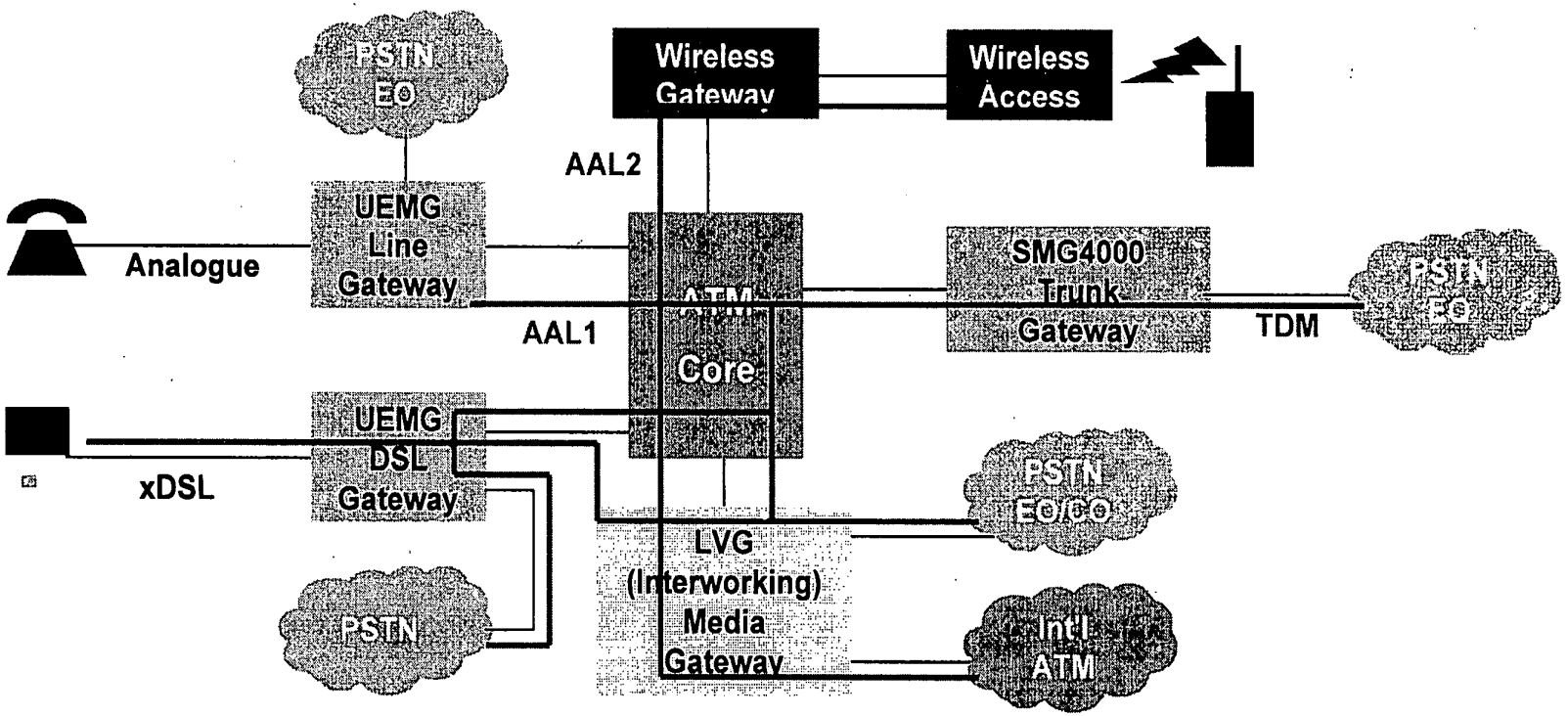
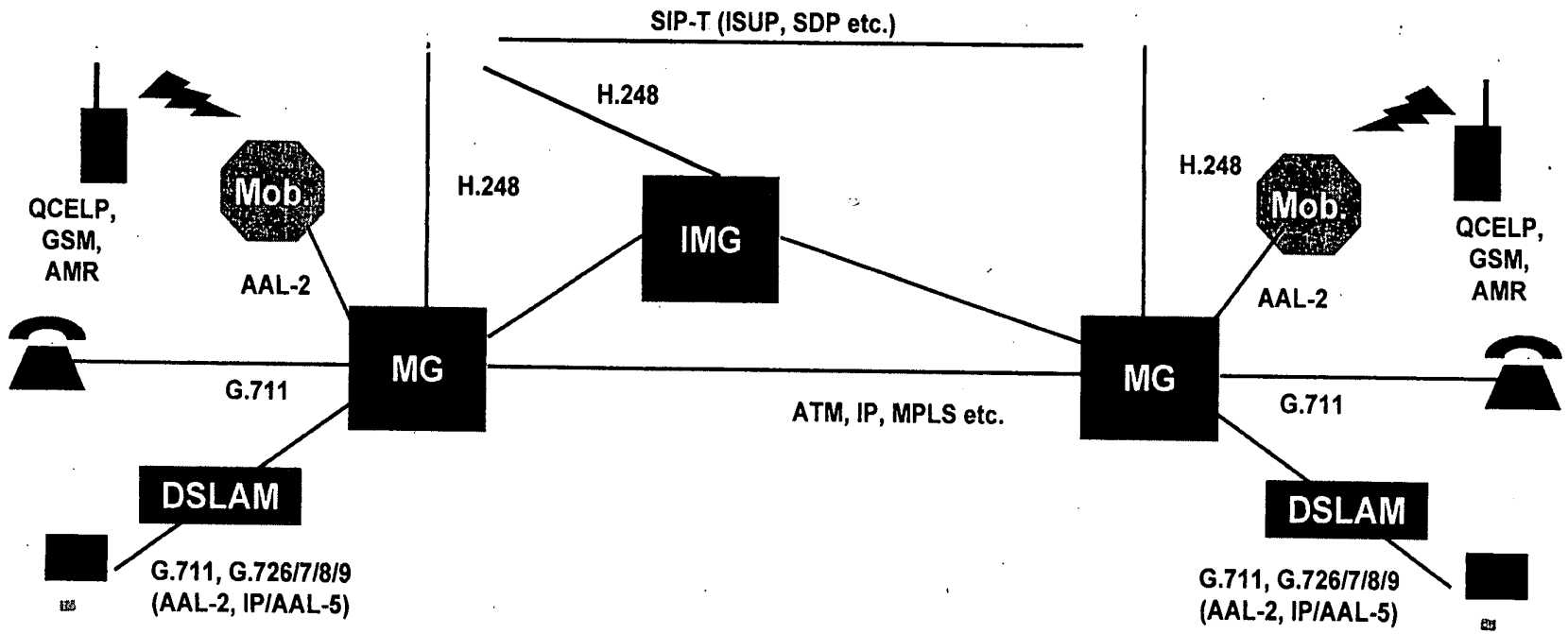


Fig. 72


SIP-T (ISUP, SDP etc.)
H.248
H.248
H.248
IMG
Mob.
Mob.
QCELP,
GSM,
AMR
QCELP,
GSM,
AMR
AAL-2
AAL-2
MG
MG
G.711
G.711
ATM, IP, MPLS etc.
DSLAM
DSLAM
G.711, G.726/7/8/9
(AAL-2, IP/AAL-5)
G.711, G.726/7/8/9
(AAL-2, IP/AAL-5)

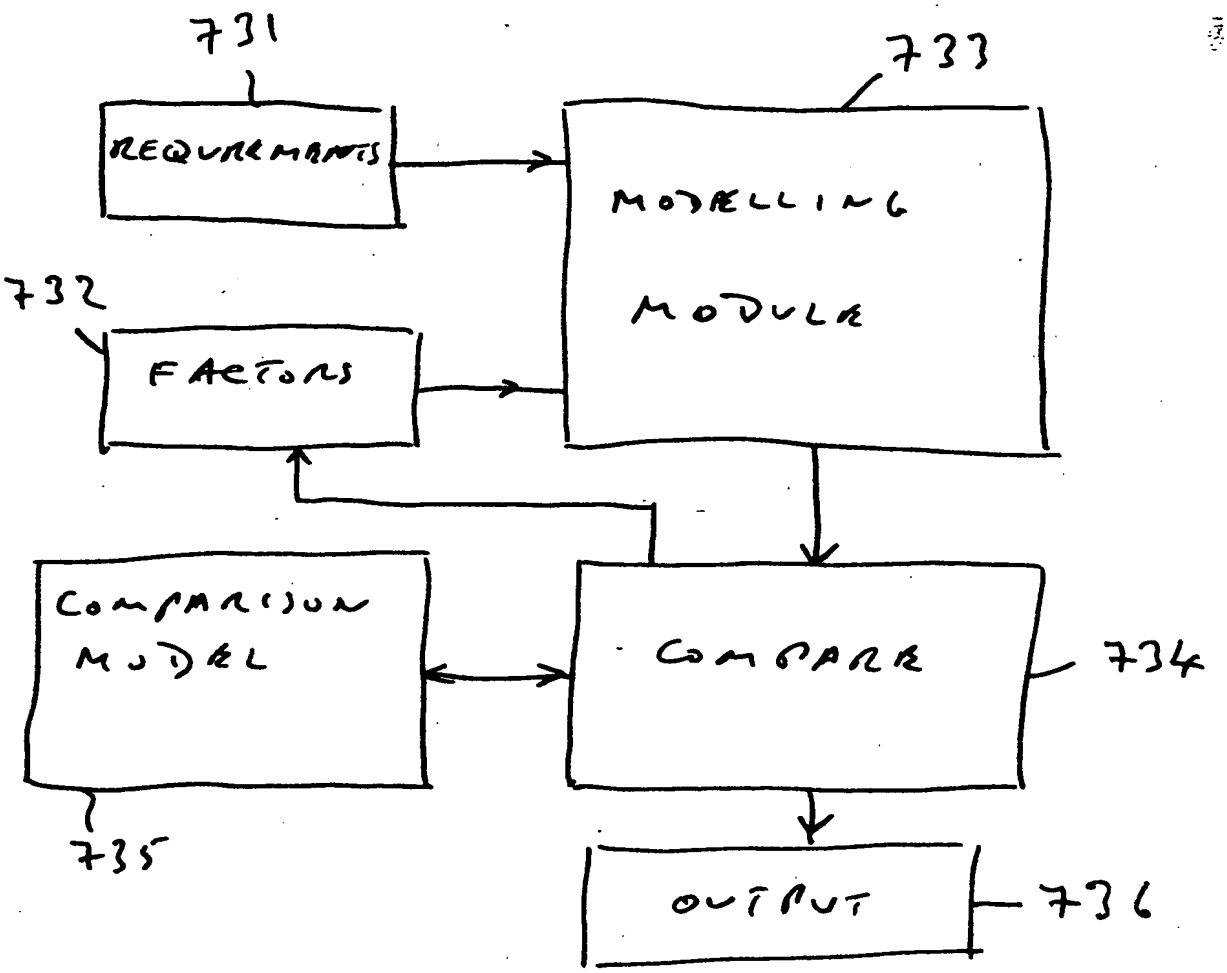

731
REQUIREMENTS
733
MODELLING
MODULE
732
FACTORS
COMPARISON
MODEL
COMPARE
734
735
OUTPUT
736

Fig 73